POWER

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How One Engineer Got His Job

Here is a plain unvarnished tale. Perhaps it is commonplace. But it is the commonplace that is oftenest vital.

The story begins when our hero was chief of a small-town water-works.

He had been there three years and was receiving $1400 per year. Being amply capable for the requirements of the position, conscientious and mildly ambitious, the need of bending to the whims of amateur supervision and conforming to petty political restrictions became somewhat irksome and he decided to cast about for a berth at least more congenial if not more remunerative.

A classified ad in a daily of a nearby large city brought a letter one morning which stated that if he was familiar with the installation and operation of apparatus usually found in a small plant it might be to his advantage to call on Mr. X.

After an interview long enough to convince Mr. X that the candidate was thoroughly competent, the former suggested that they look over the plant, situated in the basement of a recently erected six-story loft and manufacturing building and consisting of three tubular boilers, two small generators and the usual complement of other apparatus.

When the engineer saw that the plant was well arranged and that its operation would obviously be satisfactory from every viewpoint, he decided he wanted the position even at a lower salary. But, getting down to terms, the owner rather discouraged him by saying, "I'll give you $1000 the first year and a raise of $100 each succeeding year."

"Such terms are out of the question."

"All right," replied Mr. X, "I'll have to get another man. A half dozen have been in here, any one of them willing to work for $900."

"I don't doubt that," said the candidate. "If you wished, you could get a man for $780. But to hire a low-grade man to take charge of your new, high-grade machinery, simply because you can get him for little money, is shortsighted indeed. You didn't buy the cheapest equipment you could; you gave some weight to service and efficiency. Now, in buying the services of an engineer it is doubly important to secure efficiency, because while a good engineer may be able to get fair results with poor equipment, a poor engineer can never get even ordinary results with a first-class plant."

"Your argument sounds good," said Mr. X. "I'll tell you what I'll do. I'll give you $1100 per year to start."

"In view of my present circumstances, that is not satisfactory," said the engineer, "but I will start on that basis on two conditions. First, if, after three months, you will raise my salary $10 per month if my work proves satisfactory; if not, you are to pay me off and that will be the end of the matter. Second, if you will give me all I save in the cost of fuel for one year, based on normal operating conditions."

After taking two days to think it over, Mr. X agreed to this proposition.

This engineer has had the position for three years now, is receiving $1460 per year, and the end is not yet. Besides, he received $254 for the coal saved during his first year's operation.

In addition to the management and operation of the power plant, he has complete charge of the building, acting as Mr. X's personal representative.

Mr. X will shortly erect another building requiring a separate power plant. The supervision of the new plant will fall to the present chief and the added responsibility will unquestionably bring increased remuneration.

This engineer's work is congenial; he suffers few annoyances and no indignities. He is young, steady going and industrious. His future is assured.

Many an engineer drawing double or even treble this man's salary may well be envious.

Good Record for Small Isolated Plant

By F. L. Johnson

SYNOPSIS—With a rate of 2c. per kw.-hr. for power and 8c. for lighting from the central station and doing its own heating, the Renton Heel Co. decided to install a 75-kw. generating set. With coal at $3.50 per ton it made a gross annual saving of 27 per cent., or a net earning on the investment of 18 per cent.

Whenever a change is made from central-station to private-plant service, or the other way, the operating engineer is always interested, not only in the reasons which led to the change, but also in the results of that change.

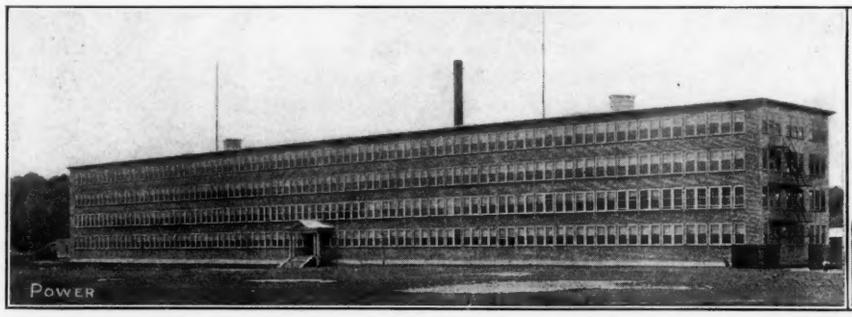


Fig. 1. Factory of the Renton Heel Co.

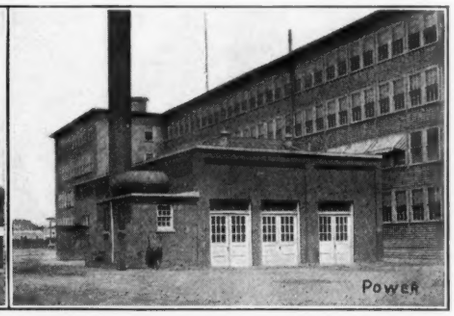


Fig. 2. The Power House

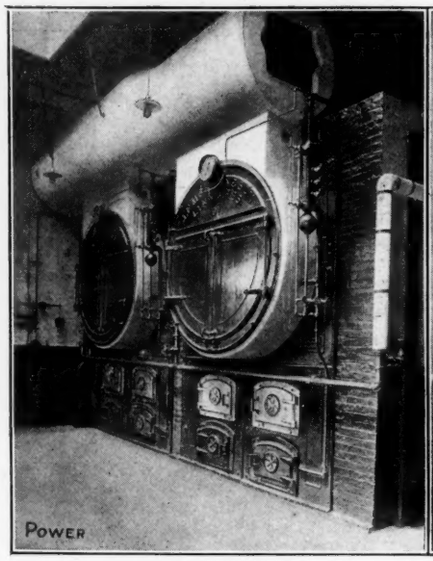


Fig. 3. Hodge Boilers Equipped with Coppus Blowers

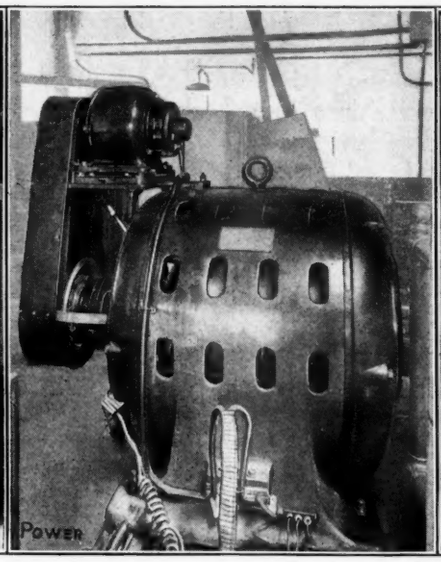


Fig. 4. Wagner 75-Kw. Alternator with Belted Exciter

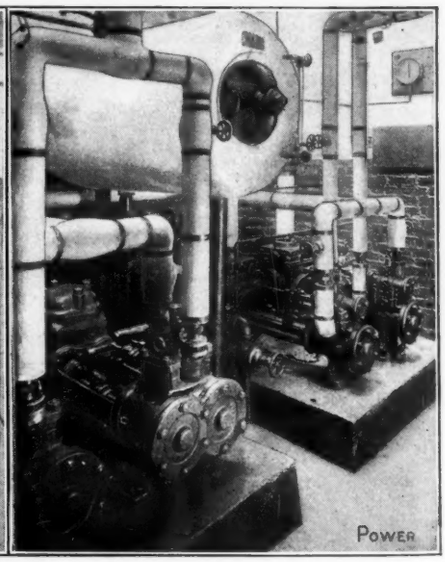


Fig. 5. Boiler-Feed and Vacuum-Return Pumps

When in 1911 the Renton Heel Co., of Lynn, Mass., decided to erect a new factory building, the management having in view the small amount of power required, was somewhat uncertain whether it would prove cheaper to buy or generate the current used. In erecting the boiler house, room was left at one end for the installation of a high-speed engine with a direct-connected generator if it should become evident that it would pay to generate current instead of buying it.

Early in December, 1911, the new four-story factory of the company containing about two acres of floor space, was equipped with Wagner induction motors, some thirty in number, varying in capacity from 1 to 15 hp., and totaling in the aggregate about 60 kw. By Jan. 1, 1912, the plant was operating at near its full capacity of 100,000 pairs of heels and 60,000 pairs of counters daily. Current was supplied by the central station at the rate of 2c. per kw.-hr. for power and 8c. per kw.-hr. for lighting. Steam for heating, drying and other purposes was furnished by one of the two horizontal return-tubular boilers which were installed at the start.

As the coal and power bills came in each month, it was seen that central-station current was proving to be an expensive luxury during those months in which it was necessary to buy coal for heating purposes, and after several consultations with local engineers operating isolated plants the management decided to put in a steam-driven generator.

During the preliminary work involved in the selection of suitable apparatus, it developed that a high-speed engine and generator would cost a great deal more than a medium-speed engine and belted generator. As the floor space provided for the generating unit was rather limited for the larger engine, it was necessary to run the belt back past the engine cylinder and mount the exciter on

the armature frame of the generator. At a cost of $9000 for foundations, generator, piping, switchboard, belting and necessary wiring to connect the new system with the old, the generating plant was installed.

After a few preliminary runs, the outfit was put into regular service on the first working day of January, 1913, and though the story is told some months before the first full year of private service is accomplished, the cost may be compared with the corresponding period of the preceding year and the sequel read as easily as though the record for the whole year was available.

Unusual care was taken in the selection of the power-plant equipment and no choice was made without deliberate discussion of details and visits to plants where the chosen apparatus was in successful operation. Following is a list of the equipment:

ENGINE—Rollins, simple, high-pressure, double-eccentric, 14x36-in., running at 128 r.p.m. Rated horsepower 168.

GENERATOR—Wagner three-phase. 60-cycle, 75-kw., 240-volt, 300-amp., running at 600 r.p.m.

EXCITER—Crocker-Wheeler, 4.3-kw., 34.4-amp., 125-volt, running at 1600 r.p.m.

BOILER—Two horizontal return-tubular, built by Hodge Boiler Works, East Boston, Mass., in 1911. Length, 19 ft. 6 in.; diameter, 72 in.; 124 tubes, 3 in. by 18 ft.; shell plates, $\frac{15}{32}$ in.; thickness of heads, ½ in.; longitudinal joint, quadruple-riveted butt, strength of joint to solid plate, 94 per cent.

CHIMNEY—Iron, 90 ft. high, 42-in. diameter. Draft accelerated, when required, by Coppus turbo-blower. Lawrence damper regulator.

PUMP—Boiler feed, two 6x4x6-in. Knowles duplex steam-driven; vacuum pumps for elevating returns to the receiver, two 5½x8x7-in. Knowles simplex steam-driven; power pumps for supplying roof tanks, three ¾x 4-in. Deane, double, electrically driven; Watson injector No. 9.

Water is heated for factory service by an independent exhaust-steam heater, automatically controlled at a temperature of 170 deg. F. Both the wet and dry systems of automatic sprinkling for fire protection are employed in the several buildings. The starting control for the dry system is located in a separate building in the yard and is electrically operated and connected with the district telegraph office, so that any interference with the system or the closing of any hand valve is promptly noted and investigated.

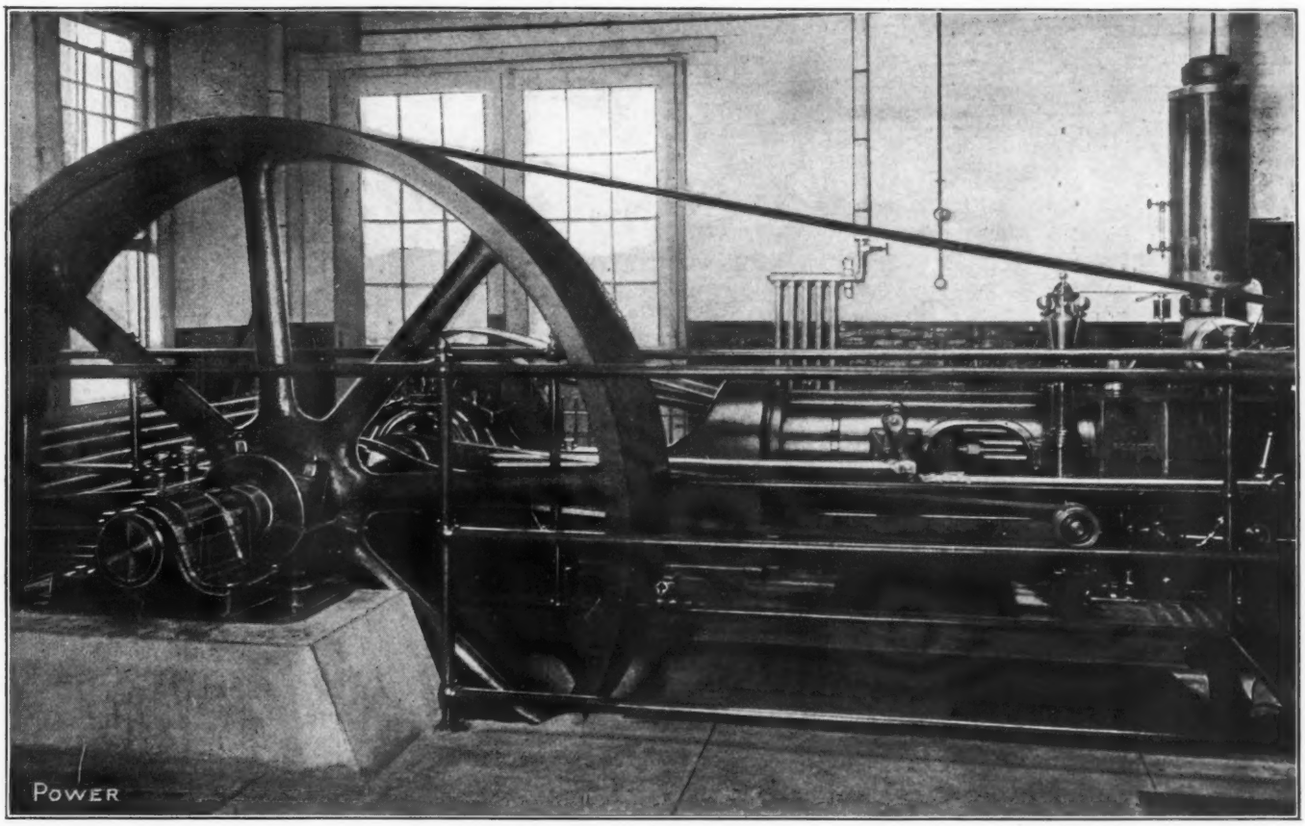


FIG. 6. ROLLINS MEDIUM-SPEED BELTED ENGINE

Complete reports of operating expenses for only the first four months of the year 1913 are available at this time, but when compared with the corresponding period of 1912, they show that even if actual loss is incurred during the four summer months of May, June, July and August, the total gain will pay a high rate of interest on the investment.

For the first four months of each of the years 1912 and 1913, the operating expenses, including coal, current, labor and supplies, were $2533.45 and $1304.84, respectively, which shows a gross saving of $1228.61.

COMPARATIVE OPERATING COSTS

	1912	1913	Gross Saving	Int. & Dep.	Net Saving
January	$771.77	$371.64	$400.13	$105.06	$295.07
February	682.84	355.38	327.46	105.06	222.40
March	587.13	306.98	280.15	105.06	175.09
April	491.71	270.84	220.87	105.56	115.81
Totals	$2533.45	$1304.84	$1228.61	$420.24	$808.37

The net profit was $808.37 for the first four months of the year 1913. It is fair to assume that the last four months will show an equal profit, and if the summer months, during which no heating is required, only pay expenses, the net profit for the year will amount to $1616.75, or about 18 per cent., on the investment after the interest and depreciation are deducted, or a gross earning of over 27 per cent.

Steam Traps on Exhaust Lines

By W. H. Wakeman

An oil separator on an exhaust pipe line running from a feed-water heater to the heating system in a machine shop is shown in Fig. 1. The drip pipe from the separator which discharged oil and grease to the sewer was made with a loop as indicated by the dotted lines. Its purpose was to prevent a waste of steam, and as long as there was a slight pressure above the atmosphere on the line it was not objectionable, although not very efficient.

The air valves on the radiators and coils in the heating system were much larger than usual and discharged into a pipe line connected with a pump. The object was to keep the line pressure below that of the atmosphere, so that when an air valve opened it would discharge water and air rapidly. Sometimes these air valves would not close promptly, hence the pressure would be reduced in the coils and radiators, also in the main exhaust pipe and separator by the operation of the pump until it was lower than atmospheric pressure. As the loop was usually nearly full of oil, etc., from the separator, it would be

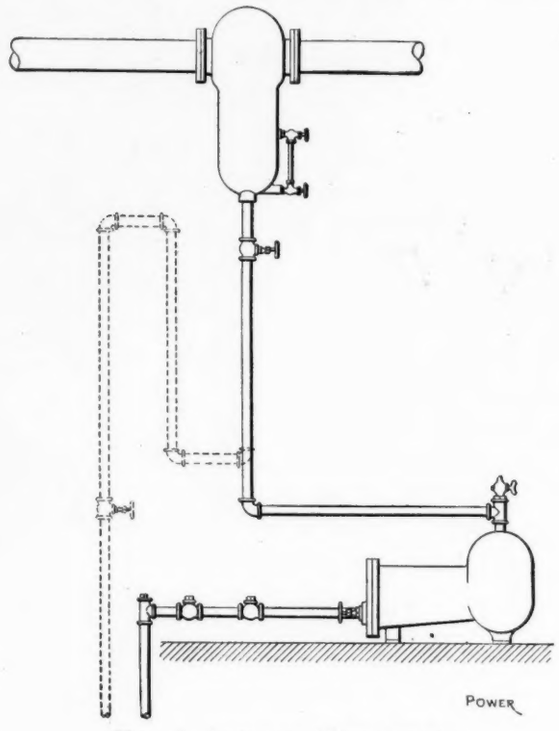


Fig. 1. Old and New Piping

drawn back into the heating system when this reduction of pressure occurred, and in due course of time appear in the boilers.

To overcome this defect the loop was removed and an ordinary ball-float steam trap installed, on the outlet of which two swing check valves were placed as shown. The arrangement operates as follows: Under normal conditions with a slight pressure above the atmosphere in the heating system, oil and water from the separator drains through the drip pipe and fills the trap until the valve opens and discharges to the sewer. When pressure

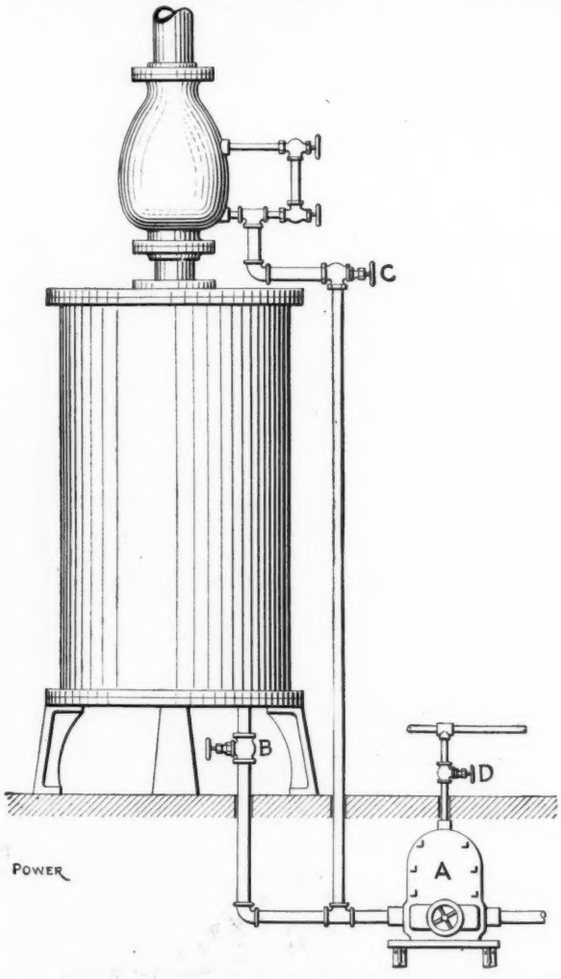


Fig. 2. Trap Connected to Heater and Drip Pipe

in the exhaust pipe is reduced below that of the atmosphere, the tendency is to draw this foreign matter up into the separator and exhaust pipe again, but the check valves close and prevent it.

The separator is about 8 ft. above the trap, and as water collects and cools it exerts 3 lb. pressure to open the check valves. This is usually more than sufficient to balance the reduction of pressure in the exhaust pipe (below atmospheric pressure), hence the trap discharges to the sewer. When this height of water is not sufficient, there can be no backward movement for the reasons already given. In practice it prevents oil from going to the boilers.

In another plant where the pressure is always equal to or above that of the atmosphere, the feed-water heater and separator were fitted with drip pipes as shown in Fig. 2, but the trap *A* was not included in the original installation. When exhaust steam was not required for heating purposes the valves *B* and *C* were left wide open, but when the engine exhausted into the heating system under 2 lb. pressure much heat was lost through these two drip pipes.

To prevent this loss the valves *B* and *C* were nearly closed until the volume of escaping steam was greatly reduced. If these valves were open just enough to allow the condensation to escape when no water was pumped through the heater, the result was satisfactory, but when the pump was started, causing much more condensation to settle to the lowest point, the nearly closed valves would not allow it to escape, and thumping and pounding in the exhaust pipe resulted. If the valves were opened enough to allow this water to escape, then much steam was lost at other times; if this water did not escape, there was the immediate danger of wrecking the engine.

To overcome this trouble the steam trap *A* was installed and now the drip valves are always open. As this trap is below the engine-room floor, a small pipe is connected to the top and extends through the floor as shown. If the trap becomes air-bound, the valve *D* is opened and the air quickly escapes. When a large quantity of water is going through the heater much steam is condensed, but the trap allows the resulting water to escape. Nothing but water that is unfit for boiler use goes to the sewer.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—We visit several mines and see more centrifugal pumps in operation. An interesting method of hoisting mine water at a rate of 2000 gal. per min. was also investigated. The engine used to hoist this amount of water was the largest we had seen, having two 36 by 60-in. high-pressure cylinders.

Two days after my last talk with Hunter we planned to visit a mine where water was handled by a huge bucket and a winding engine. There were some things I still wanted to know about centrifugal pumps, however, for it appeared to me that with their simplicity, light weight, large capacity and ease of connection to a motor they were ideal units. From my limited observation of the two pumps I had seen operating there was no vibration or water-hammer which I had noted on the reciprocating pumps, and I so stated to Hunter.

"Right you are," was the reply. "A pump correctly balanced will run as smoothly as a watch, comparatively speaking. As you say, a centrifugal pump requires but little floor area, for the same capacity, as compared with a reciprocating pump.

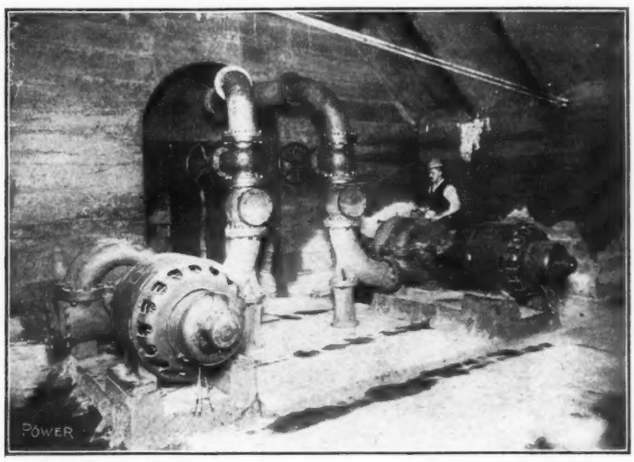


Fig. 1. Two Two-Stage Centrifugal Pumps, Capacity 1000 Gal. per Minute

"One method of running them on deep shafts is to use them as a relay system. For instance, in a shaft, say, 1400 ft. deep, the pump stations would be placed about 300 ft. apart, and each station would contain two pumps of the same capacity, one being held as a spare unit. The head would be about 325 ft. for the 1400-, 1100-, 800- and 500-ft. levels, and 200-ft. head for the pump at the 200-ft. level; each level would have a sump. The pumps would probably be of the two-stage type. In the particular mine I have in mind the capacity of each 6-in.

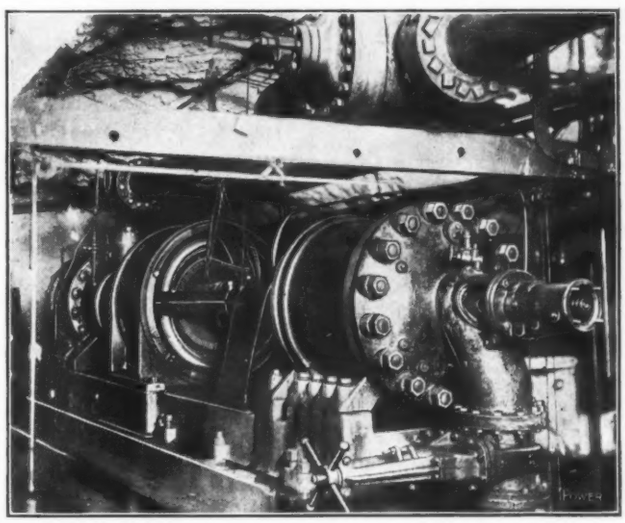


Fig. 2. Two Four-Stage Centrifugal Pumps Driven by One Motor

pump (Fig. 1) is 1000 gal. per min., with a speed of 1745 r.p.m., each driven by a 125-hp., three-phase, 60-cycle, 220-volt motor."

"So it's necessary to relay the water from one level to another. I supposed that is one of the objections to centrifugal pumps?"

"It isn't always necessary to relay the pumps," replied Hunter, "for instance, I can show you an 8-in. eight-stage pump made as one unit arranged with four stages on either side of the motor; the two sides of the pump are connected by a pipe when it is used as a series pump."

The next day we saw the pump, Fig. 2. Each set was designed for a capacity of 900 gal. per min., delivering this amount of water against a height of 1250 ft. A 450-hp. motor with a speed of 1160 r.p.m. drove the pump.

"The design of that pump," said Hunter, "eliminates a number of joints which would have a tendency to leak under pressure and the pump runner can be removed without dismantling the unit.

"As a whole, the peculiar characteristics of centrifugal pumps require special care in their selection, the motor to drive them and the method of control. In some respects the features of centrifugal-pump operation is the opposite of reciprocating pumps."

"How do you make that out?" I asked, seating myself on a piece of timber, for the climb up the hill had been long and hot.

"Because," replied Hunter, taking a seat beside me, and wiping the perspiration from his forehead "a constant speed and an increase of resistance against which the reciprocating pump works increases the pressure and the load on the water plunger. But with a centrifugal pump an increase of resistance reduces the load.

"If you are pumping a certain amount of water with a reciprocating pump and wish to reduce the amount of water discharged without changing the speed of the pump, some of the water being pumped must be bypassed. With a centrifugal pump the amount of water discharged can be reduced by throttling the discharge pipe."

"According to that statement, if the head against which a reciprocating pump is working is reduced, the volume discharged will not be affected, unless slightly by leakage, but wouldn't the power to pump the volume of water be reduced?"

"Right you are," replied Hunter. "With the volume discharged the power required to operate the pump will be less with a reduced head. But with a centrifugal pump, when the head is reduced the volume or rate of discharge will be increased as well as the required power, but the amount of increase in volume depends upon the characteristics of the pump.

"There is this fact to always keep in mind, in selecting a centrifugal pump, always know the head against which it is to work, unless the motor is provided with a speed control, because a small difference in the static head will make quite a difference in the volume of water delivered; a slight variation in speed will also produce a considerable variation in the quantity of water delivered."

After lunch we started for the mines of the Lytle Coal Co., near Minersville, where a huge mine bailer was to be seen. This shaft, or rather triple shafts (Fig. 3), is 1500 ft. deep. Coal is hoisted from two shafts, and water from the third. A 36x60-in., first-motion hoisting engine, Fig. 5, handles the mine bailer, hoisting at a rate of 2000 gal. of water per minute. The cone drum is 10 and 16 ft. in diameter. As the bailer reached the top of the shaft a tripper, attached to the side of the shaft, opened a valve at the bottom and the water was discharged as shown in Fig. 4. The tripper is shown at the sides of the bailer.

The mine superintendent stated that the mine water

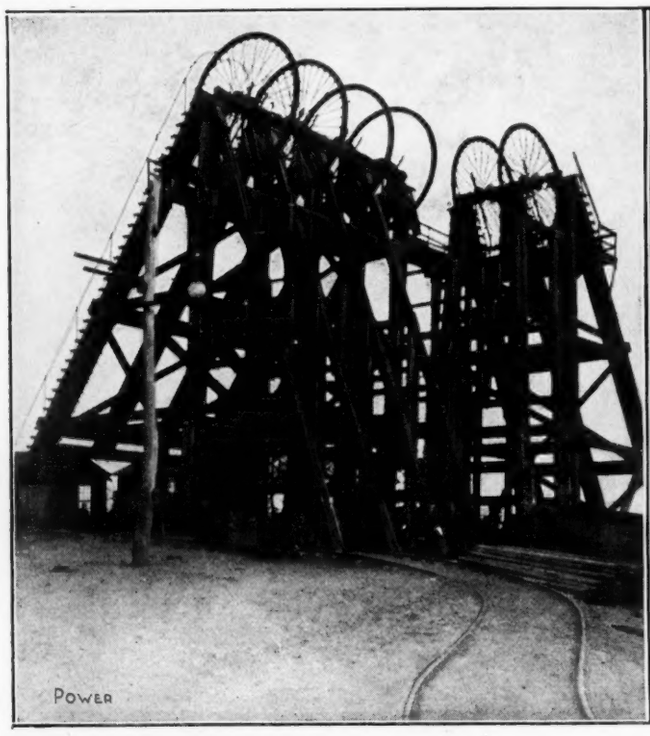


FIG. 3. TWO COAL AND ONE WATER-BAILER SHAFTS

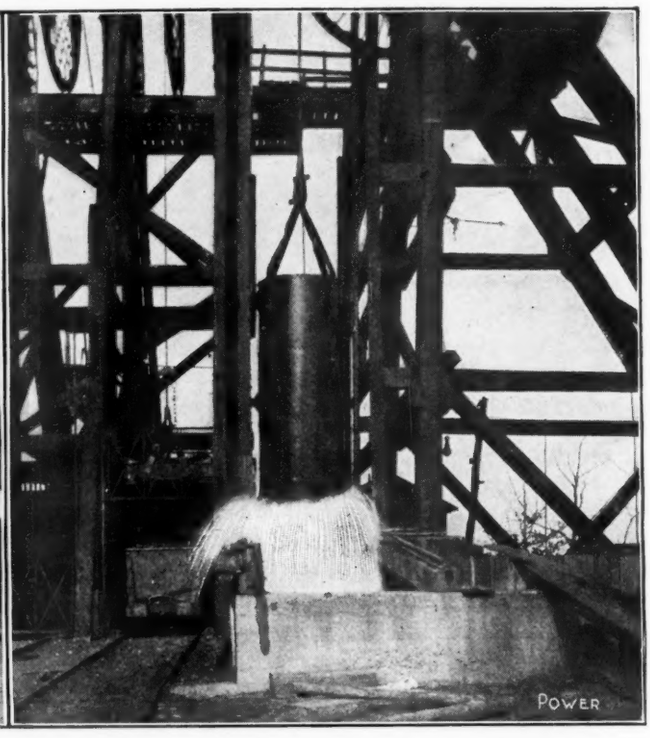


FIG. 4. BAILER DISCHARGING WATER AT A RATE OF 2000 GAL. PER MIN.

FIG. 5. A 30x60-IN. FIRST-MOTION HOISTING ENGINE

was of such quality that it did not attack the pipes in the mine, which made a big difference in the upkeep expenses.

"That goes to show," said Hunter, "that nobody knows what propositions will come up when sinking a new shaft. Now, take the next mine to this one. I am told that they have all kinds of trouble with acids in their mine water, and they are not more than ten minutes' walk distant at that."

"How do you account for that?" I asked with some surprise. "I don't," replied Hunter. "I suppose that this mine being deeper has a different water to handle, or the water in the upper seams may be prevented from reaching the lower level by a layer of hard rock. The water problem in coal mines is no small matter, you may rest assured. A few of the soft-coal mines, perhaps 20 per cent., have natural drainage, in which case the cost of operating the mine is much less than if water had to be handled by pumping."

It was late that night before we returned to the hotel, tired and hungry, after a most interesting day at the mines.

Boiler Attachments—I

By J. E. Terman

SYNOPSIS—Pointers regarding the proper location of the water column and gage-glass on various types of steam boilers, kind of piping and fittings to use in the connections.

The method of applying the various attachments required for the operation of a steam boiler is an important subject. Safety is just as dependent on the correct location and method of connecting some of these devices, as it is on the design and strength of the boiler itself. However, the inexperienced engineer often overlooks the importance of the functions performed by them and does not use the caution in their installation that he would, if due thought were given the subject.

It is intended herein to relate chiefly to the equipment of the horizontal-tubular type of boiler, but some features connected with the installation of attachments on other types will be considered. As the true indication of the water level in a boiler, is one of the most important features connected with its safe operation, the proper application of devices used for this purpose will be considered first.

Water Columns and Gage-Cocks

Twenty years or more ago, and even at the present time, along some of the principal navigable streams of the country, where the equipment of the stationary plant is still influenced by steamboat practice, it is customary to dispense with a water column and have the gage-cocks located directly on some part of the boiler, for the purpose of determining the water level. In some respects this is the best kind of equipment for the purpose; for there is no reason for doubting the indications of gage-cocks when located in this manner. There are objectionable features to this arrangement, however; the principal one of which is that water is discharged over the flue or tube ends and back connection covering, when the cocks are located at the rear, or over the boiler front, if located at the furnace end. To obviate this difficulty, the cocks are frequently attached to a piece of pipe, as illustrated in Fig. 1, so that the water from the cock is discharged clear of the rear setting wall.

This arrangement is undesirable on account of two features; the small pipes are liable to be accidentally broken off or pulled out, and if the pipes happen to be dropped slightly at the end attached to the gage-cock water of condensation will collect in the pipes connected to the steam space. If the water level is tested by giving the gage-cocks a quick twist or two, as is customary, the arrangement is likely to mislead the attendant as regards the true water level in the boiler.

The modern method of equipping a boiler for the determination of the water level is by the use of a combination water column and glass water-gage, the column being usually provided with three gage-cocks. This device is so extremely simple that it is usually regarded as unnecessary to give much thought to its installation. However, the indication of the true water level in a boiler by means of a column, while simple, is a rather delicate matter, and conditions that are seemingly of no consequence are liable to cause the indications to be dangerously inaccurate. The indication of the water level in a boiler by means of a column is due to the tendency of a liquid to seek its level, or come to a uniform height in all parts of a vessel and its connections. It is necessary that the pressure throughout be uniform for the height to be the same in all parts, and slight variations of pressure in the column connections will render the level indicated false. The need for practically absolute uniformity in pressure may be realized, when it is considered that a 2-oz. difference in pressure per square inch means a change of level of nearly three and a half inches; this change of level in the horizontal-tubular type of boiler might be sufficient to turn a condition of safety into one of danger.

Pipe connections from the boiler to the column should be as short and as direct as possible, and in size not less than 1¼ in. No attachments, except a steam-gage, should be connected to the piping of a water column; and no connections for supplying steam or water should be allowed on the water-column pipes under any pretext. The slightest flow of water or steam in the pipes of a water column will render its indications of the water level absolutely untrustworthy.

Where turns are necessary in the connecting pipes to the water space of the boiler, crosses or tees should be used in place of elbows and the unused openings plugged. These plugs may be removed and the pipes cleared of scale or other foreign matter when the boiler is washed out. Fig. 2 shows a water column properly piped for a horizontal-tubular boiler with the overhanging-front type of setting.

It is necessary to have the piping from the steam space of the boiler to the water column so arranged that there

will be no chance for water pockets. It is preferable to place the piping so that the condensation will drain toward the water column rather than toward the boiler, since this will tend to keep the column and the pipes connecting it to the water space filled with condensation, and thus assist in preventing an accumulation of scale or deposit in these pipes.

No valves should be placed in the connecting pipes to a water column, because there is too much risk connected with their use. The only reason for placing valves in these connections is to allow the thorough blowing out of the pipes and the possibility of dislodging the cause of a stoppage by this means. While this is important, the necessity of such violent cleaning can be obviated, by using properly arranged connections and making periodic examinations to see that they are clean and free. A proper-sized blowoff connection to a water column will produce sufficient current in the connecting pipes to remove ordinary obstructions, notwithstanding the absence of valves on the pipes.

The danger in having valves on the connecting pipes to a water column is, that they may either be left closed accidentally or the disk may become detached from the valve stem, causing a proper water level to be indicated on them by the settling of the walls or the expansion of the boiler under operation.

It is best to use brass piping to the water column, at least on the water end, for this will not corrode and stop up as readily as will iron pipe. The connection to the steam space of the boiler will be as serviceable if made of iron as if made of brass.

The blowoff connection to a water column should be the full size of the connecting pipes, if they are not over 1¼ in. in diameter. It is usually best to have the discharge from the blowoff enter the ashpit, but the pipe should be securely fastened to the boiler front where it passes through it. Failure to observe this precaution has often resulted in injury, as the pipes are sometimes forcibly turned around on the connections, by the reaction produced by the sudden outrush of steam and water when blowing down the column.

Water columns are usually made of cast iron, and about all that is required is that they be of suitable strength and correctly arranged for the attachment of the water-gage fittings and the gage-cocks. A column should also have ample cross-sectional area to provide sufficient water storage, so that the indications of the fluctuations in the water level, produced by ebullition in the boiler, may be

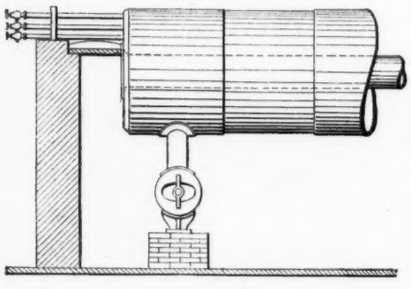


FIG. 1. GAGE-COCKS AND PIPE CONNECTIONS

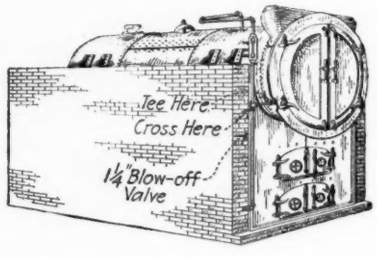


FIG. 2. BOILER AND WATER COLUMN

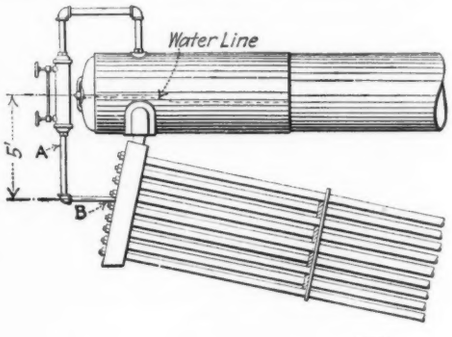


FIG. 3. IMPROPERLY CONNECTED WATER COLUMN

when in reality it is very low. There is no doubt but that a considerable number of low-water explosions could be traced to the use of such valves, if honest testimony could be obtained by those most vitally interested. No engineer, who is fit to be called such, would permit a valve between the boiler and its safety valve, and while the case is not exactly analogous, it does not appear any more logical to allow the use of such a fitting between the boiler and its water column.

With a boiler in regular operation, a warning of over pressure may be expected from the steam-gage, by the behavior of the engines or other steam-using apparatus or by leaks around the boiler or piping, before an explosion actually occurred. In the case of lack of water, only the possibility of detecting overheating could aid the attendant in preventing an accident; and it would, therefore, appear that the safeguarding of the accuracy of the indications of water level in a boiler is possibly of more importance than the correct operation of the safety valve.

When the connecting pipes of a water column are required to pass through a portion of the setting wall, as is the case with the flush-front type of setting for horizontal-tubular boilers, there should be ample clearance space left around these pipes, so that no strain can be placed on them by the settling of the walls or the expansion of the boiler under operation.

It is best to use brass piping to the water column, at least on the water end, for this will not corrode and stop up as readily as will iron pipe. The connection to the steam space of the boiler will be as serviceable if made of iron as if made of brass.

The blowoff connection to a water column should be the full size of the connecting pipes, if they are not over 1¼ in. in diameter. It is usually best to have the discharge from the blowoff enter the ashpit, but the pipe should be securely fastened to the boiler front where it passes through it. Failure to observe this precaution has often resulted in injury, as the pipes are sometimes forcibly turned around on the connections, by the reaction produced by the sudden outrush of steam and water when blowing down the column.

Water columns are usually made of cast iron, and about all that is required is that they be of suitable strength and correctly arranged for the attachment of the water-gage fittings and the gage-cocks. A column should also have ample cross-sectional area to provide sufficient water storage, so that the indications of the fluctuations in the water level, produced by ebullition in the boiler, may be lessened. Some types of boilers require longer columns than others: for example, on a large vertical-tubular boiler the water level will fluctuate through a much wider range than on a horizontal-tubular boiler.

A 22- or 24-in. gage-glass may be found to be best suited to the former, while a 12- or 14-in. glass might be entirely satisfactory for the latter boiler. Gage-glasses are easily broken, usually by sudden changes of temperature, caused by a blast of cold air. Means must be provided for conveniently installing new glasses. For this purpose, the water-gage fittings are always equipped with valves which may be closed to prevent the outrush of steam and hot water.

There are a number of devices on the market for automatically closing the water-gage connections when a glass breaks; but these are not infallible and are liable to produce false indications of water level; their use has been wisely prohibited by the Massachusetts Boiler Rules in that state. The most satisfactory arrangement of shut-off valves for the water-gages is to equip them with chain pulls so that the valves may be closed from the floor level and save the attendant the necessity of dodging a stream of steam and hot water, as is the case when these valves must be operated directly by hand. The chain pulls are even of greater utility when opening the valves after

putting in a new glass, for the operator is out of range of the flying pieces in the event of the glass breaking. It is a dangerous proceeding to put a new glass under pressure while the face is in proximity to it, as can be attested by many an unfortunate who has been injured at such times. There seems to be an uncontrollable desire to look directly at a new gage-glass when opening the valves, to see if it will withstand the pressure. Unless chain pulls are provided for the water-gage valves, the attendant should protect his face with a shield of metal or wood, or close-woven gauze or heavy glass, if the desire to see can not be overcome. The bottom valve admitting water should be opened first; afterward the steam valve, very slowly, until equilibrium has been established, after which this valve can be opened wide.

There are a variety of good gage-cocks made, the writer preferring the type that is closed by a weighted lever provided with a piece of sheet packing which may be easily renewed as required.

Location of Water Column and Gage-Glass

A water column should always be located so that it will cease to indicate the water level before a point of danger has been reached. This means that all surfaces swept by flames or highly heated gases should be protected on the inside surfaces by water, as long as the water-glass or gage-cocks give indications of its presence. A common and safe rule for locating the water column on a horizontal-tubular boiler is, to have the lowest point of vision in the gage-glass about one-half inch above the upper side of the top row of tubes, and the lowest gage-cock about three inches above the same point. When taking measurements for the location of the water column with respect to the tubes, it is necessary to see that the tubes are level across the boiler at both ends, and if not, suitable allowance should be made in locating the column, so that the highest exposed point will be protected.

The brick walls on the side of a horizontal-tubular boiler are generally closed in along the shell, considerably below the top line of tubes, and the rear head and tube ends are usually the first points where the effects of low water are felt. While a water level at a point as low as ½-in. above the tops of the tubes would appear as hazardous, it is not as close to the danger line as it would seem. In the first place, this type of boiler should be set with the rear end about 1 in. lower than at the front, and since the rear upper tube ends are one of the first points to require protection; this makes about 1½ in. of water above them when there is ½ in. in the gage-glass. As an actual fact, there are several inches of water above the rear tube ends under the above conditions of water level when the boiler is in operation, due to the violent ebullition produced under running conditions.

The exact location of the safe water line in the usual type of vertical-tubular boiler can not be stated, for it depends to a large extent on the amount of grate area compared with the heating surface, and also the draft available for burning the fuel. For ordinary boilers of this type, which are usually of small capacity, the limit established by the Massachusetts rules for the minimum height of water line, viz., one-third of the tube length above the crown sheet, is probably safe. This could hardly be considered safe, however, for large vertical-tubular boilers of the Manning type, containing relatively large grate areas and long tubes, and often equipped with forced-draft appliances or stokers.

For such boilers, probably two-thirds of the tube length above the crown sheet would be required to furnish sufficient heating surface to reduce the temperature of the gases to a point which would not be likely to overheat the portion of the upper tube ends that are protected only by the steam. The safe water level for the various types of water-tube boilers may be determined by bearing in mind the general principle that surfaces opposite those exposed to highly heated gases must be in contact with the contained water.

Care must be used in selecting a point to make the water connection to a column on a water-tube boiler, to guard against false indications being shown. Rapid currents produced by the circulation at some of the most accessible points for making such connections, might seriously affect the correctness of the indications.

In some types of boilers it is common practice to extend an internal pipe to a point where the steam has been completely liberated from the water, in order to secure a true indication of the water level.

It is a common idea that the pressures in all parts of a boiler are equal, except for the differences in pressure due to the depth below the water line at any point. While this is perfectly correct, as long as the water is in a quiescent state, it is not true under operating conditions. The violent circulation of the water in a boiler, which can not be properly appreciated, until its ability to move loose metal parts is noted, is directly due to differences of pressure in the various parts. These differences in pressure are produced by the difference in

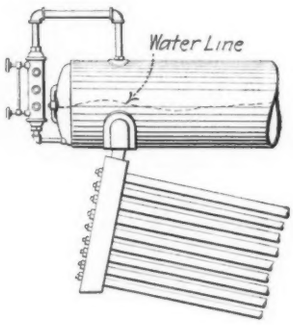


Fig. 4. Properly Attached Water Column

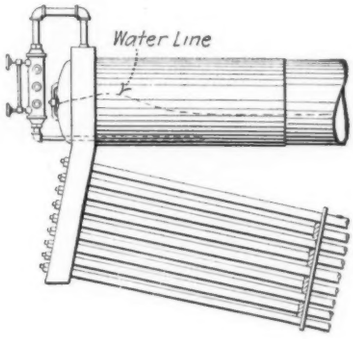


Fig. 5. Another Water-Column Connection

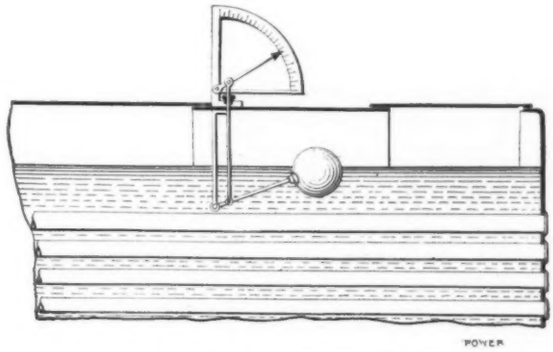


Fig. 6. Float Water-Level Indicator

specific gravity of the contents at various points, caused by the variations in the amount of steam bubbles mixed with the water at such points.

While the differences in pressure produced by this means may be insignificant when compared with the total pressure carried, they are very real and effective in causing incorrect indications of water level, which may become dangerous with a change of a few inches. To illustrate, suppose that the water connections to a water column on a Heine or a boiler of similar type, should be made at the center of the front header as illustrated in Fig. 3, and that the distance from the water line to the point of connection was 5 ft., as shown. Also assume, for the purpose of illustration, that this boiler was operating at a rate that would cause the contents of the header and throat connection immediately above it and up to the water line, to be one-half steam bubbles, the weight of which can be assumed as nothing, as compared with that of an equal volume of water.

Under these conditions, when the true waterline was at the center of the drum, as illustrated, the water level in the connecting pipe to the column would be at some point as at *A*, where the weight of the solid water in the pipe would just balance the pressure at the point of connection to the header *B*. Of course, there are many other factors that would affect the level of the water in the column pipe, such as, the discharge from a tube near *B;* or the velocity of the current up the header and the consequent frictional resistance to be overcome. The arrangement of the end of the pipe at *B* with respect to the currents flowing up the header would also have considerable influence on the indication of water level in the column connections, but it can be seen that a column, connected to this kind of boiler in the manner described, could not possibly indicate the correct water level while the boiler was in operation under the assumed conditions.

Other things being equal, the best arrangement for the connections of a water column to a boiler, especially if it is of the water-tube type, is to have the water connection reasonably near the waterline, for then the differences between the density of the water in the column connections and in the boiler will have the least effect on the indications shown by the column. In the Babcock & Wilcox type boiler, where there is a considerable overhang of the front drum ends beyond the header nipples, a connection directly on the steam-drum head is satisfactory. Such a connection is illustrated in Fig. 4. In the Edgemoor type of water-tube boiler it is generally necessary to connect an internal pipe to the water connection to the column, as shown in Fig. 5, to prevent interference with the indications by the circulation. In either case of the two types just mentioned, a water column connected at the rear end of the boiler would probably be more satisfactory, if it were not for the fact that it could not be readily seen by the firemen. The waterline under operating conditions, if no baffle-plates were used, is probably about as illustrated in Figs. 4 and 5 for the Babcock & Wilcox and Edgemoor type of boilers.

A water column should be blown down at least twice a day, to remove any sediment that may have lodged in the pipes, and to test the freedom of the connections by noting how rapidly the water returns to its original height in the gage-glass. When the connections to a column are free, and of ample size, there will be a constant movement of the water noted in the glass during operation. This movement is caused by the disturbance of the water level in the boiler produced by the liberation of steam, and this movement can also be used as a check against possible stoppage of the column connections or those to the gage-glass; a quiet waterline should be looked on with suspicion.

When installing a water column on a horizontal-tubular boiler, the positions that the flue doors occupy when open must be noted. If the water column can not be located in a proper position without interference by these doors, suitable stops should be provided, to prevent the doors from striking the columns when opened. It should be remembered that a water column is a most important attachment and it must be placed in a location where it can be readily seen from practically every point on the firing floor, and if the boiler room is at all dark, a light should be placed so that no mistake in reading the indications of the column can be made. The gage-glass should be kept clean, as a soiled section is liable to be mistaken for an indication of water.

There have been other devices for indicating the water level in a boiler, besides gage-cocks, and viewing the waterline through a gage-glass; but none of these attachments have proved very satisfactory. A number of years ago a float arrangement, as illustrated in Fig. 6, was used to some extent, but owing to numerous difficulties connected with its operation, it could not be depended on for correct indications of water level. It was practically impossible to maintain in good order the stuffing-box where the rod passed through the shell, so that it would be tight and at the same time free enough to permit of its being actuated by the weight of the float. There was also considerable difficulty in obtaining floats of sufficient strength to prevent collapse, without their being too heavy for the purpose. This apparatus, even when working at its best, could not give a true indication of the water line. The quadrant over which the indicating hand moved was graduated in inches and half inches.

Wydawake Damper Regulator

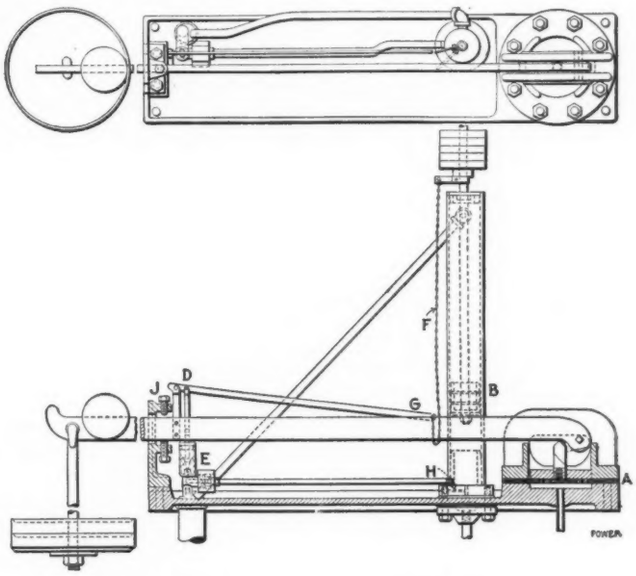
This very simple regulator has but three main parts, the cylinder with its piston, the diaphragm and the relief valve. The regulator is mounted on a heavy cast-iron base and the cylinder is of brass fitted with a piston and leather cap. There are two sets of weights, one for the main adjustment, the other for the fine adjustment. The apparatus is illustrated herewith.

In operation the steam acts on the diaphragm *A*. With the steam at the normal pressure the piston *B* will be at the bottom of the cylinder. When the steam pressure decreases under the diaphragm the main lever drops and carries the arm *D* with it, which action closes the water-relief valve *E*. This causes the water pressure to force the piston *B* toward the top of the cylinder, which opens the damper.

As the piston approaches the end of its stroke, it pulls the chain *F* taut, which lifts the short lever end *G*, and slightly opens the relief valve *E*, releasing the pressure under the piston *B*, which is held in its position until the steam pressure has reached normal at which the regulator is adjusted.

When normal steam pressure has been reached the pressure on the diaphragm lifts the main lever which action

operates the relief valve and releases the water pressure in the cylinder, and the piston descends, due to the weights on it, and closes the damper.



DETAILS OF WYDAWAKE DAMPER REGULATOR

The water supply to this regulator, which is made by the L. J. Wing Manufacturing Co., 352 West Thirteenth St., New York City, is controlled by the screw *H*. The only other adjustment is at the screw *J*, which controls the lift of the main lever.

Experience with a CO_2 Recorder

BY HENRY R. BLESSING

Before a CO_2 recorder was installed in my plant I used to make practical observations which, while proving satisfactory, as far as making steam was concerned, were doubtless not productive of very high economy. The water-tube boilers are fitted with vertical baffles—the last pass is down, and there are four passes. The furnaces are mechanically fired, and front-feed inclined grates are used.

Before the CO_2 recorder was set up, I made observations of the fire to ascertain the condition for steaming. I had read that a white, dazzling color is the hottest, but it was not the most economical in my case, as a light-orange color gave the best results. My explanation is that the dazzling flame carried with it an excess of air, the first pass receiving most of the heat, and with the infiltration of air through the setting, the gases in the last pass were too cool to produce good results.

I also found that a light fire would give a white, dazzling color in the furnace. All that was visible in the upper part of the first pass was the reflection from the furnace below, and nothing seemed to go over the baffle into the second pass. With a fire thick enough to produce a light-orange color in the furnace a longer flame was obtained, which could be seen going over the top of the baffle and part way down the second pass.

With this condition steam could be held better, which convinced me that the light-orange color was best suited for existing conditions. When the CO_2 recorder was installed I expected to see a high per cent. of CO_2, but the highest obtained was 3 per cent. Then I blamed the machine which recorded CO_2 only, but after testing, it was found correct.

The sampling pipe was then changed, entering the rear setting in and terminating over a division wall to the dampers. A tee was screwed on the end of the old pipe and a piece of perforated pipe screwed in each branch having a plug at each end; thus the sample was drawn from the full width of the last pass.

After this change an increase in the percentage of CO_2 was obtained, but not what was expected. Every crack was stopped up, no matter how small, in the setting, around the furnace floor frames and wherever air might leak in, after which 10 per cent. CO_2 was obtained, but no matter what was done this was the most that could be had, often less.

Later, while watching the machine record some samples, the needle registered 15 per cent. CO_2 and stayed there until it unloaded, thus recording on the chart the highest per cent. yet obtained. The recorder is in a separate room and, going to the boiler room, I found the man who cleaned the tubes had the tube blower stuck in the lower hole in the first pass just over the furnace and in line with the combustion arch.

Here was a problem to solve. Before the CO_2 machine was installed I had to increase the thickness of the fire to prevent too much air passing through the grates, and now the tube blower showed that more air was needed. It appears that before the use of the CO_2 recorder enough air leaked into the furnace to satisfy combustion. After the cracks were stopped up all air had to pass through the grate, the air spaces in which were found badly clinkered, thus retarding the air supply to the furnace.

This suggested admitting more air in front of and over the coking plate and mixing the air with the gas before it came in contact with the combustion arch, the amount of air to be regulated to suit the conditions of the grate and the kind of coal burned.

Control of Furnace Draft

BY EVERARD BROWN

The efficiency of a boiler and consequently its economical operation, depends upon the right proportion of air admitted to the furnace, or, in other words, upon a proper draft.

For the purpose of such draft regulation the damper is used in connection with natural-draft systems, and while it may not be quite as effective as some other means of regulation, it will, if properly handled, make for better furnace operation and fuel reduction.

For example, if the boilers do not have a full load, the dampers may be partially closed, thus reducing the intensity of the draft and diminishing the rate of combustion of fuel on the grates. If they are subjected to a fluctuating load, the dampers, when attached to regulators, will automatically close as the demand for steam decreases and the steam pressure increases, thus preventing the boiler safety valves from blowing. If the load is constant and the grate area is in proportion to this load, the damper becomes of less importance.

Dampers are usually located in the uptake flue and are sometimes arranged to regulate the admission of air below the grates. Two dampers, one in the flue and

one in the ashpit, however, will probably give the best control, as the former will regulate the admission of air over the fire or through the door grids, in hand-fired boilers, and the latter will control the passage of air through the fuel bed. Many careful firemen, for example, will partially close the ashpit dampers after firing, so that, if necessary, the flow of air through the door grids will be increased. These two dampers should give perfect control over the combustion, providing there is always sufficient stack draft, and their proper handling should reduce the amount of smoke and coal bills to a minimum.

For individual control and operation in a plant of two or more boilers, each should be equipped with a draft-regulating damper. This will permit of pushing any boiler that might lag behind the others and in this way get the most out each individual boiler. Where there are automatic nonreturn valves on each boiler, however, this is rather difficult, because the damper will automatically open when the pressure goes down, and for the same reason the valve will close; thus they tend to oppose each other.

The usual procedure in such instances is to connect the damper regulator to the main steam line or to the main header, which results in the loss of the individual boiler-control feature that would otherwise obtain and which is always desirable.

Fairbanks Renewable Seat Valves

Although iron-body and brass-body gate valves have been put on the market for some time by the Fairbanks Co., 416 Broome St., New York City, the renewable seat-ring feature is new.

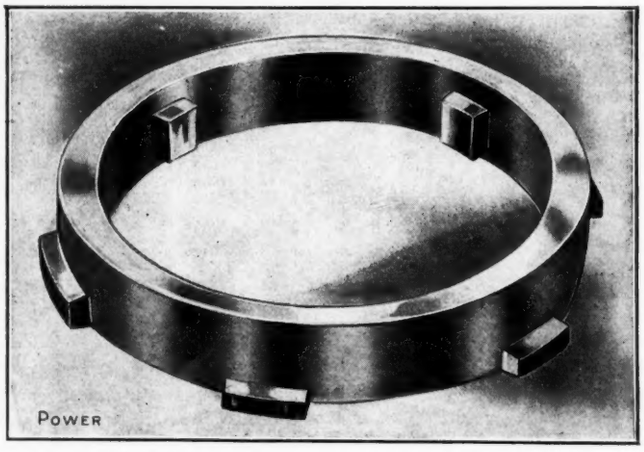


FIG. 1. SEAT RING FOR REMOVABLE IRON-BODY GATE VALVE

The renewable seat ring, Fig. 1, is made of bronze and is held in the body casting by specially constructed cut threads and lock in place similar to a gun breach block. The seats can be changed by the use of a wrench. The seat rings engage with the bronze face of a double-taper solid wedge, and pressure may be applied to either side of the valve.

A view of the renewable iron-body gate valve is shown in Fig. 2. The seat-ring feature permits of expansion and contraction.

In Fig. 3 is shown a phantom view of the renewable-seat brass gate valve. The seat rings are separate pieces, engaging in a recess cut in the lower portion of the valve body and held in place by a saddle, machined to fit on the

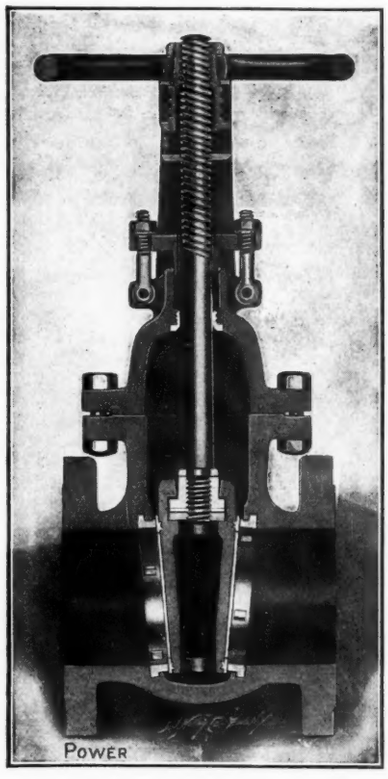


FIG. 2. REMOVABLE RING IN IRON-BODY GATE VALVE

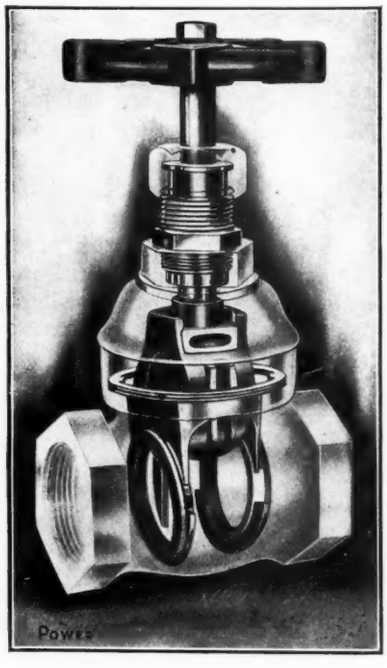


FIG. 3. PHANTOM VIEW OF BRASS GATE VALVE

upper surface of the rings; the saddle is held firmly to its position by a locking ring screwed into the body thread. Both types of valves are made in stationary and rising-spindle types.

ELECTRICAL DEPARTMENT

Transformer Characteristics—II

By Edward T. Moore

Efficiency

The efficiency is the ratio of the output to the output plus the losses, and if for each load the losses are known, the efficiency is easily determinable. The core losses which depend upon the density of magnetism are constant for a constant internal electromotive force, but, except for capacity loads, decrease to a negligible extent as the transformer is loaded. Hysteresis loss can be reduced only by decreasing either the density of magnetism or the volume of the core, both of which decreases soon reach a limit in any practical transformer. The loss due to the eddy currents varies as the square of the thickness of the laminations. These laminations are coated with "japan" or varnish, which serves to insulate the individual sheets sufficiently to prevent a cross-current between them. As the insulation and the normal coating of oxide require an appreciable portion of the total space when the laminations are very thin, the space area for active lines is reduced in a given cross-section, so that for a constant number of lines through the core, the actual magnetic density is increased by the presence of insulation when the laminations are subdivided. Modern practice has almost accepted 14 mils as standard thickness for transformer plates, for 60 cycles, while for 25 cycles thicker sheets are frequently employed.

For a given transformer the copper loss depends entirely upon the current in the primary and secondary coils. Since to transmit energy at a given rate requires a larger current when the power factor is low than when high, energy can be most efficiently transmitted by the transformers when the power factor is unity, or 100 per cent.

Assuming a constant internal electromotive force at all loads, the total transformer loss is made up of a constant loss and a loss varying as the square of the currents. With noninductive load, the increase of copper loss with load is almost independent of the exciting current which may be considered as producing merely an additional core loss at all loads. The efficiency will, therefore, be a maximum for that load at which the variable losses equal the constant losses. Transformers designed to operate continuously at full load usually have the point of maximum efficiency occur at that load. For many systems, the transformers must operate the larger part of the time on light loads and reach full or overload for only a relatively small time, for which service, the core loss is the determining element for the efficiency, while the copper loss is of relatively small moment. For other systems, the regulation is of prime importance, so that the copper loss is the determining element.

Temperature Rise

The loss in a transformer appears as heat in the windings and core, which must be dissipated as fast as generated in order to prevent excessive rise in temperature. In small transformers, the heat is dissipated sufficiently by radiation and convection in the surrounding air, but as the rating increases, the surface increases more slowly, so that large transformers if cooled by air alone would become much warmer than small ones. Therefore, it is necessary to supply some auxiliary cooling medium, and for this purpose, oil has been found well adapted, while its excellent insulating and puncture-repairing qualities render its adoption further desirable. When necessary, the oil is further cooled by the circulation of water in pipes immersed in the oil, or the oil is pumped from the transformer and cooled before being returned to it. Another common method of artificially cooling transformers is by means of a blast of air directed so that it will pass through ducts between the section of the core and the subdivision of the coils, and between the coils and core.

Since the specific heat of the air is 0.2375 and air weighs 0.0807 lb. per cu.ft., there is required 0.01915 B.t.u. to raise the temperature of 1 lb. of air 1 deg. F., or 0.0345 B.t.u. to change the temperature of 1 cu.ft. of air 1 deg. C. Since 1 kw. of power represents a transfer of 56.9 B.t.u. of energy per minute, each kilowatt of loss would require 1650 cu.ft. of air per minute to hold the temperature rise at 1 deg. C. Experience has shown that for most installations, a temperature rise of 15 deg. C. between the entering and leaving air is permissible. Therefore, in operating the air blast without the aid of direct radiation, there would be required for each kilowatt of loss, 110 cu.ft. of air per minute. It is customary, however, to allow 150 cu.ft. of cooling air per minute for each kilowatt loss. The required amount for any transformer can be easily calculated from the efficiencies. For instance, a 500-kv-a. transformer having a full-load efficiency of 98.2 per cent. would have a loss of 1.8 per cent., or 9 kw.; hence would require $9 \times 150 = 1350$ cu.ft. of air per min. In specifying a blower set for a group of transformers, it is advisable to calculate the amount of air required by the transformer at 125 per cent. load, and to add about 5 per cent. to this calculated amount to allow for leakage in the air chamber and passages. The pressure at which the air should be supplied to the transformers depends on the size, voltage and frequency, as the lengths and therefore the resistance of the ventilating ducts depend on these values; the pressure, however, will not ordinarily vary between the limits of ½ oz. and 1½ ounces.

For water-cooled transformers, the cooling pipes are made without any seam or joint within the tank, and they are kept wholly below the upper surface of the oil in the tank. The tubing is usually from 1 to 2 in. in diameter, the length depending upon the amount of heat to be carried away and the difference in temperature between the oil and the water. The cooling surface of the pipes required will depend also upon the amount of heat which

the external surface of the core will dissipate, but it may be stated that the surface of the pipes in contact with the oil varies from 0.5 to 1.3 sq.in. per watt of total transformer loss. The amount of water required depends on the difference in temperature of the incoming and outgoing water. Each kilowatt-minute of energy to be carried away represents 56.9 B.t.u., or 56.9 lb. of water raised in temperature 1 deg. F. For a temperature rise of 24 deg. C. in the water, there would be required 1.32 lb. of water per minute per kilowatt of loss. Estimating the weight of water as 8.30 lb. per gal., each kilowatt of loss would require each minute 0.158 gal. of water changed in temperature 24 deg. C. For instance, a 500-kv.-a. transformer having a full-load efficiency of 98.2 per cent. would have a loss of 1.8 per cent., or 9 kw., and this would require $9 \times 0.158 = 1.42$ gal. of water per minute.

Transformers cooled by forced-oil circulation are used to a large extent for large units above, say, 1000 kv.-a. The heated oil is pumped from the top of the transformer and the cooled oil is forced to enter the ducts in the transformer windings and core at the bottom. For the purpose of directing the course of the cold oil, the lower end of the transformer is inclosed and the only outlet for the oil is upward through the ducts. The rate of circulation is limited solely by the ability of the pump to move the oil. The saving in cost of the complete transformer equipment when forced-oil circulation is substituted for forced-water circulation may be as high as 25 per cent. for 10,000 kv.-a. units, but it practically disappears for units as small as 1000 kv.-a.

Regulation

Regulation is the percentage increase in the secondary voltage of the transformer as the load is decreased from its normal value to zero, the primary voltage being held constant at the normal value. It is usual to assume in making a test that a transformer will be operated at a unity power factor. Such, however, is not always the case and to cover all conditions, it should be noted that the losses depend upon the volt-amperes, quite independent of the power factor. Thus, at 75 per cent. power factor the losses are the same at 75 per cent. load as they would have been at 100 per cent. load for 100 per cent. power factor. Moreover, the regulation depends very largely upon the power factor; it is much worse at 75 per cent. load and 75 per cent. power factor than it is at 100 per cent. power factor and 100 per cent. load. Therefore, in making a full-load test of a transformer, it is desirable, and in many cases necessary, to duplicate the actual conditions under which the transformer is to operate.

Frequency

Any 60-cycle transformer can be operated at a higher frequency and at the same voltage with a slight decrease in the iron loss and a corresponding improvement in the efficiency. The relative change in the iron loss of a transformer as the frequency is varied is shown by the curve in Fig. 8.

Although for a constant impressed electromotive force, the iron loss increases as the frequency is lowered, it is possible to operate any 60-cycle transformer at a much lower frequency without any increase in iron loss by decreasing the voltage slightly. With constant impressed electromotive force, the eddy-current loss is independent of the frequency, while the hysteresis loss varies inversely as the 0.6 power of the frequency. At constant frequency, the hysteresis loss varies as the 1.6 power and the eddy-current loss as the second power of the electromotive force.

Neglecting the change in eddy-current loss with a change in the voltage, the voltage for constant iron loss varies as the three-eighths power of the frequency. That is, if when the frequency is doubled the voltage is increased by 29.7 per cent., the iron loss is not altered and the hysteresis loss is the same, but the eddy-current loss increases by 29.7 per cent. Likewise, when the frequency is lowered by 50 per cent. the electromotive force is decreased by 22.9 per cent. the iron loss is unchanged and the hysteresis loss is the same, but the eddy-current loss is decreased by 22.9 per cent. Thus, a 2200-volt, 60-cycle transformer can be operated at about 2850 volts at 120 cycles, or at about 1700 volts at 30 cycles, without any appreciable change in the iron loss. It is to be noted, however, that the transformer must be provided with additional high-tension taps for these percentages above and below normal voltage, as standard transformers are generally supplied only with high-tension taps for approximately 3, 6 and 9 per cent. below normal operating voltage.

A 25-cycle transformer operating on a 60-cycle circuit will have its regulation impaired somewhat and if the load is composed of induction motors, their torque will be reduced. This difficulty, however, is not so serious

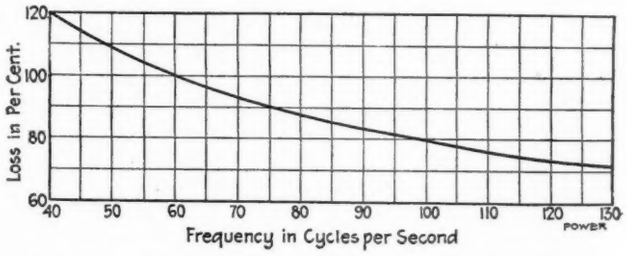


Fig. 8. Variation of Iron Loss with Frequency

with a synchronous motor load as power-factor conditions are much higher. For example, assume a 375-kv.-a., 25-cycle transformer operating on a 60-cycle circuit of 80 per cent. power factor, the regulation would be approximately 5.5 per cent. instead of 2.8 per cent. were it operating on a 25-cycle circuit. With a synchronous motor load and 100 per cent. power factor, these transformers operating on 25 cycles would have a regulation of 1.05 per cent. and 1.5 per cent. on a 60-cycle circuit. This poorer regulation could be compensated for by making use of a high-tension tap to raise the low-tension voltage by 5 per cent.

Insulation Tests

Insulation tests are made according to the following table which is based on the "Standardization Rules of the American Institute of Electrical Engineers":

Rated Terminal Voltage of Circuit	Test Voltage
Not exceeding 549 volts	5000
Exceeding 549 but not exceeding 5000 volts	10,000
Exceeding 5000 volts	Double rated terminal voltage of the circuit

The rated terminal voltage of the circuit is the voltage between the conductors of the circuit to which the transformer is connected. From this it follows that where

single-phase transformers are to be connected in star on a three-phase circuit, the line voltage and not the transformer voltage determines the test voltage. An exception may be made to this in case the neutral point is to be connected directly and permanently to the ground. The transformer voltage (the voltage from the neutral point to the line) may then be considered as determining the test voltage. The test between the high- and low-tension windings is the same as that between the high-tension winding and the core, and both tests are made simultaneously with the low-tension winding connected to the core. The duration of the test is one minute. A test is then made between the low-tension winding and the iron for one minute. In addition to these tests, 200 per cent. of normal voltage is impressed on the low-tension winding for 5 min., with the high-tension winding not connected to either the low-tension winding or the core. This test induces double normal voltage throughout the windings and thereby subjects every part to double the normal stresses.

New Insulating Material

A new material known as "Micarta," to take the place of hard fiber, glass, porcelain, hard rubber, built-up mica, pressboard, rawhide, molded compounds, etc., has been developed by the Westinghouse Electric & Manufacturing Co. It is used for commutator bushings and brush-holder insulation, as noiseless gear blanks, as conduit for automobile wiring, as spools for spark coil and magnet windings, for refillable fuse tubes, for wireless coil separators, for arc shields in circuit-breakers, for water-meter disks, etc.

It is a tan-brown, hard, homogeneous material having a mechanical strength about 50 per cent. greater than hard fiber, and can readily be sawed, milled, turned, tapped or threaded, if a sharp-pointed tool is used and the work is done on a lathe. It can be punched only in thin sheets and cannot be molded. Micarta is not brittle and will not warp, expand, or shrink with age or exposure to the weather, but takes a high polish, presenting a finished appearance.

Two grades of the material are made. The grade known as "Bakelite" Micarta will stand a temperature of 300 deg. F., continuously, or 500 deg. for a short time. It is infusible and will remain unaffected by heat until a temperature sufficient to carbonize it is reached. Heat will not warp Bakelite Micarta, and it will stand an electric arc better than hard fiber, hard rubber, built-up mica, or any molded insulation containing fibrous or resinous materials. Its coefficient of expansion is low, being approximately 0.00002 per deg. C.

Bakelite Micarta is insoluble in practically all of the ordinary solvents, such as alcohol, benzine, turpentine and weak solutions of acids and alkalis, hot water and oils. It is indifferent to ozone—an advantage over hard rubber, resins, etc., for electrical purposes. It is nonhydroscopic and impervious to moisture.

The other grade designated as No. 53 Micarta has the same mechanical and electrical properties as the Bakelite Micarta, but differs in its chemical and thermal properties. It behaves toward chemicals and heat very much as an ordinary resin. This grade is not used in plate form.

CORRESPONDENCE

Hunting of Generators

In answer to A. N. Kerr's request for information as to the probable cause of his generators hunting when running in parallel, I would state that it might be due to one or two causes out of several. It is well to remember that when two or more alternating-current generators are run in parallel, that the division of the load between them depends primarily upon their speed-load characteristics. Therefore, it is essential that the two Harting governors act freely and equally sensitive for the same relative loads, so that the tendency would be to divide the load properly when operated in parallel.

Mr. Kerr does not state how the exciters are connected—individually or in parallel—at the switchboard. If the exciters are for individual operation only, I would suggest that an e.m.f. chart be taken for both exciters, from similar current readings. If everything else is all right, such as both belts being in perfect running condition, commutators and brushes smooth and properly set, and the speed equal, then the e.m.f. curve should keep the same for both machines. If it does not, the compound winding on the exciter having the higher e.m.f. should be shunted to balance with the lower characteristics of the other exciter.

If the power factor is low, or the load variable, then the use of a small synchronous motor connected to the main busbar would be an aid to improving the power factor.

Regulators are a great help in maintaining the exciter voltage in proper relation to the generator load. This is especially true when load variations are great and frequent.

BEN DAWSON.

Cedar Rapids, Iowa.

I have the following to suggest in regard to A. N. Kerr's trouble with hunting (see POWER, Sept. 2, 1913).

He should first ascertain the speed of each machine by the formula

$$R.p.m. = \frac{120 \times frequency}{number\ of\ poles}$$

Having done this he should adjust the governor on the small engine sensitive and that on the large engine sluggish; or it may be necessary to make both governors somewhat sluggish if the machines do not remain in step with one governor sensitive and the other sluggish.

If surging still continues, make the admission earlier on the small engine on one end only (the head end is preferable) or the compression may be reduced on the head end of the large engine.

The foregoing have proved successful in overcoming hunting in our plant.

V. K. STANLEY.

Ponca City, Okla.

Electricity Cheap in Switzerland—Cheap power, widely distributed in Switzerland, has led to the introduction of small motors mounted wheelbarrow-wise for farm and similar uses. A complete installation of a 1-hp. motor, starting box, speed-change gears and pulley, barrow mounted with 10 meters (about 33 ft.) of cable, costs about $90.

GAS POWER DEPARTMENT

The First Diesel Locomotive

The first locomotive to be propelled by a Diesel engine was designed and built at the works of Messrs. Sulzer Bros., in Winterthur, Switzerland, and delivered by them some months ago to the Prussian-Hessian State Railway of Germany. We are indebted to the builders for the accompanying description and drawings together with photographs of the complete locomotive as it appears in service.

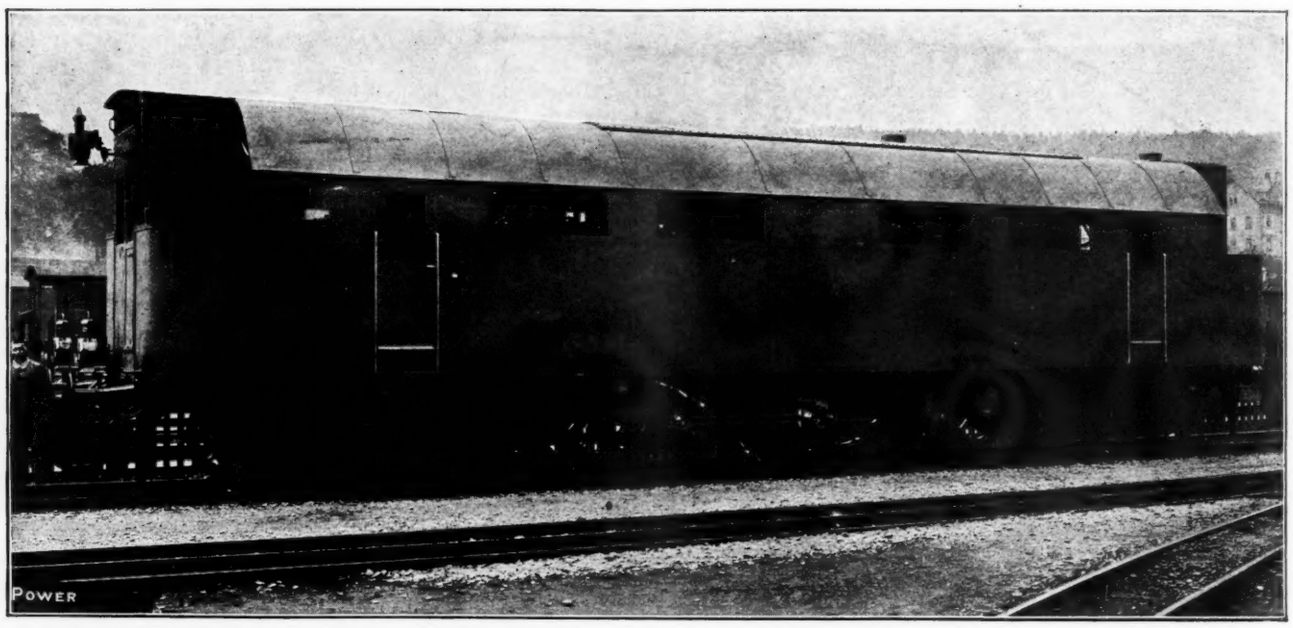


FIG. 1. SIDE VIEW OF SULZER-DIESEL LOCOMOTIVE

In substance the basic idea is a propelling engine direct-connected to the axles of the driving wheels and, independent of it, a complete auxiliary engine of about one-fourth the capacity, serving for the production of compressed air with which the main engine is started and which, with late cutoffs, is also supplied to it under certain running conditions, as ascending steep grades, etc. That the service rendered by the auxiliary engine may be at times increased, air reservoirs are provided from which, with the auxiliary at rest or in operation, a further supply of air can be taken.

While starting, the auxiliary engine is kept running, thus uninterruptedly furnishing a relatively large flow of compressed air for setting the main engine in motion; adding to it from the air reservoirs as may be needed. By means of the compressed air alone the train is accelerated to a speed of five or six miles per hour. The fuel is then admitted, the air cutoff and the engine operated on the normal Diesel cycle.

The locomotive has a length of 54.4 ft. and weighs in service 95 tons. The two trucks have a wheel base of 7.2 ft. and the rigid wheel base is 11.8 ft. From center to center of the truck center pins measures 32.8 ft., and the driving wheels have a diameter of about 69 in.

The motive effort is transmitted from a crankshaft to the driving wheels by means of side rods, the ends fitted with adjustable boxes.

A Westinghouse brake equipment is included and applied to both the driving and the truck wheels and in addition a toggle-joint hand brake is provided for the former. The air for braking is taken from the intermediate stage of the compressor and is stored in a special reservoir, and pneumatic sanding appliances are provided for use in either running direction.

For the protection of the equipment the cab is continuous over the full length of the locomotive. In each corner is a tank, three for cooling water and one for fuel storage, and in the roof, over the main engine, is the exhaust muffler. Two coolers for the circulating water are provided as are also two pumps driven either by the main or by the auxiliary engine, one for circulating the cooling water and the other for supplying the fuel.

The motive power is furnished by a Sulzer-Diesel, reversible, four-cylinder, single-acting, two-stroke-cycle engine. The cylinders are arranged in pairs, each inclined 45 deg. from a line perpendicular to the rail surface, their axes intersecting in that of the single crankshaft common to all; they have a bore of 15 in. and a stroke of 21.65 in. Each pair of opposed cylinders lies in a common plane and acts on a common crankpin and that such action may be entirely symmetrical the crankpin end of one of the opposed connecting-rods is forked. The two cranks are set at 180 deg. and at 60 miles an hour make slightly over 300 r.p.m. Pressed in place on each

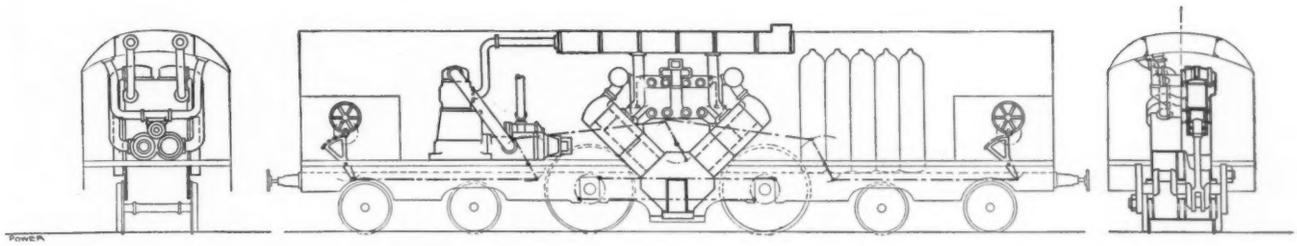


FIG. 2. SHOWING ARRANGEMENT OF ENGINES AND AUXILIARIES

end of the crankshaft is a counterbalanced crank disk transmitting its rotation to the driving wheels. By this arrangement a complete balance is obtained between the primary forces of reciprocation emanating from the main cylinders, and the centrifugal forces of the cranks, side rods and counterweights.

Each cylinder head carries a fuel valve, a starting valve and two scavenging valves, admitting air under 700 to 1000 lb., 700 and 20 lb. respectively. The exhaust is through ports in the cylinder walls, opened and closed

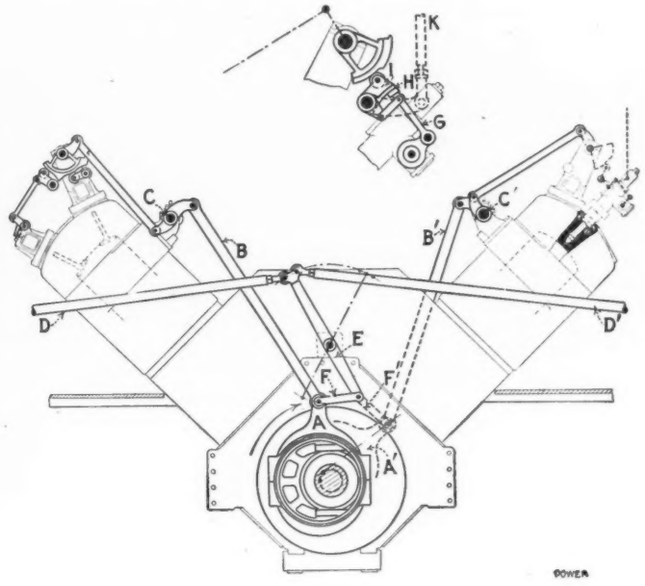


FIG. 3. SHOWING ECCENTRICS AND LINKS FOR ACTUATING VALVES

by the main pistons. Between the crank disks and the frame are two eccentrics of which each one controls all the valves of one-half of the main engine and is rotatable for reversing the running direction, which is accomplished through a special linkage system, *DEF*, Figs. 3 and 4. The position of the lever *E*, represented by the solid lines, corresponds with forward running, that by dot-and-dash lines with reverse. By means of the rods *B* and *B'*, the motion of the two eccentrics is transmitted to the rockshafts *C* and *C'*, which actuate the valves in the cylinder heads. On the right-hand cylinder of Fig. 3 the gear for the fuel-admission valve is indicated; on the left-hand cylinder that for the scavenging valves. The control of the fuel-inlet valves is such that different admission volumes can be had, effected by varying the position of the free end of the rod *G* along the sliding contact surface *H* of the roller arm *I* by means of the reach rod *K*, thus governing the open position of the fuel-inlet valve.

The starting valves are operated in like manner as shown in Fig. 4. The open period of these valves must naturally be greater than that of the fuel-inlet valves, the period being determined by rotating the shaft *H* on which the bell crank *O*, Fig. 4, is eccentrically journaled. Placed in the starting pipe *K*, just ahead of the starting valve in the cylinder head, is another valve *L* which, as to its time and travel, is unvaryingly actuated by a cam secured to a vertical shaft driven through miter gears by the side rod *M* and controlled by the connection *R*. The provision of two controls for the starting air accomplishes the possibility of constant lead and the lowering of losses by throttling effect. With but one starting valve per cylinder it would be difficult to so arrange the

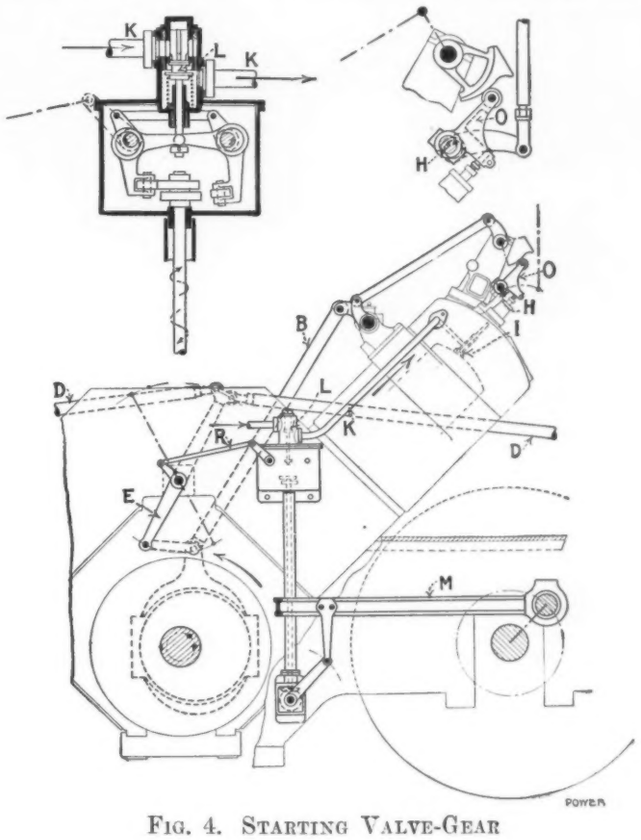


FIG. 4. STARTING VALVE-GEAR

valve-gear that constant lead would result throughout the range of cutoff, in this case from 0 to 60 per cent. Further, the wire-drawing resulting from the unavoidable failure to obtain a quick opening and closing of the main starting valve would introduce important losses. The duplex gearing described eliminates these disadvantages.

Fig. 6 is a diagram of the coincident opening, lifting and closed positions of the two valves controlling the admission of the air for starting throughout a revolution

of the main crank; *AB*, indicating the curve of successive positions of lift of the initial valve *L*, and *CD*, those of the starting valve proper, *I*, for maximum, reduced and minimum cutoffs by that valve.

It is characteristic of this valve-gear that the curves *CD* of the main valve are symmetrical each side of the line *PP'*, radial to the crank circle. From this it is seen, on the one hand, that for all cutoffs the main valve is wide open at the dead-center position of the crank; hence

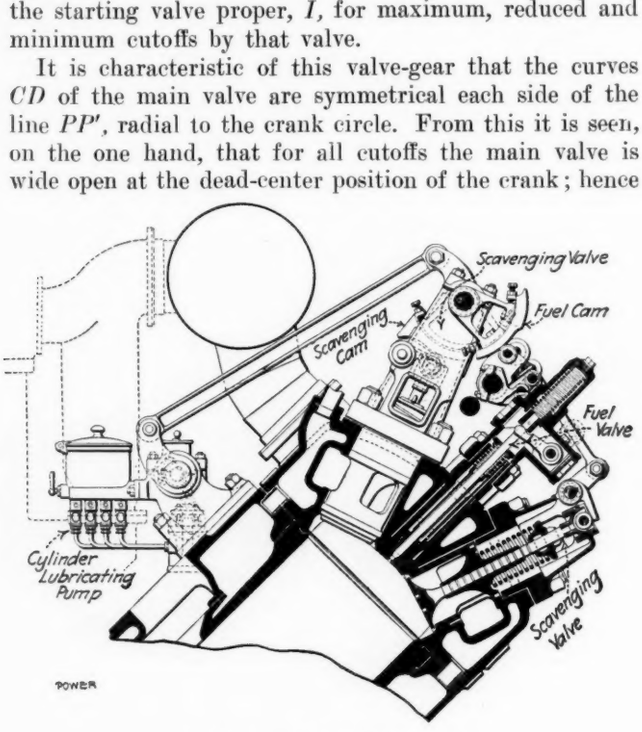


FIG. 5. VALVE DETAILS

the initial air admission is determined by the valve *L;* and, on the other hand, by using such gearing, reversal of the main valve is unnecessary and a change in the running direction is secured by reversing the action of the primary valve *L*.

Between the four main engine cylinders are the double-acting piston pumps and a three-stage air-injection pump for spraying in the fuel. All three pumps are driven from the connecting-rods of the front pair of main engines through the medium of rocker-arms and links and all are fitted with relief valves. The air-injection pump is in the nature of a reserve for the main compressor as, in the event of the latter being incapacitated through any cause, it is capable of supplying the injection air under conditions of normal speed and not too high a duty.

The auxiliary engine is likewise a two-stroke-cycle machine of 250 hp. It has two vertical cylinders 12 in. in diameter and 15-in. stroke, fed by a duplex fuel pump. The crankshaft has two counterbalancing flywheels, and two cranks 180 deg. apart and these latter, through other connecting-rods, actuate two horizontal, multi-stage air pumps; see Fig. 7. By means of a distributing valve the delivery of the compressor can be regulated from zero to maximum, and a governor controls the speed of the compressor engine between 200 and 350 r.p.m.

With the locomotive stopped or under service requiring but little air the compressor delivers its surplus output into receivers placed behind the main engine.

The air as delivered from each stage of the compressor is diverted through a cooler. From the high-pressure cooler the air is conducted to a distributor whence by valves it is led to various points as desired; one connection leading to the starting-air reservoirs, another to those for the injection air, and a third to the reserve reservoirs. These latter, through the distributer, are in turn in communication with the auxiliary engine, as are also the fuel-injection air reservoirs, for the purposes, respectively, of setting it in motion and maintaining it in operation.

For lubrication special pumps are provided. The amount can be regulated for each cylinder, and all crankshafts and connecting-rod boxes and all needed points within the crank cases are provided with forced lubrication; the oil being drawn from the crank cases, filtered and forced through piping to the required places.

Hand-operated centrifugal pumps are included for priming the cold water, circulating water and fuel piping when needed. A fourth pump is for lubricating inside the crank case when the locomotive is at rest.

An operating room is provided at each end of the housing for the engineman where are located the various actuating mechanisms, such as the lever for throwing into and out of action the starting and fuel valves,

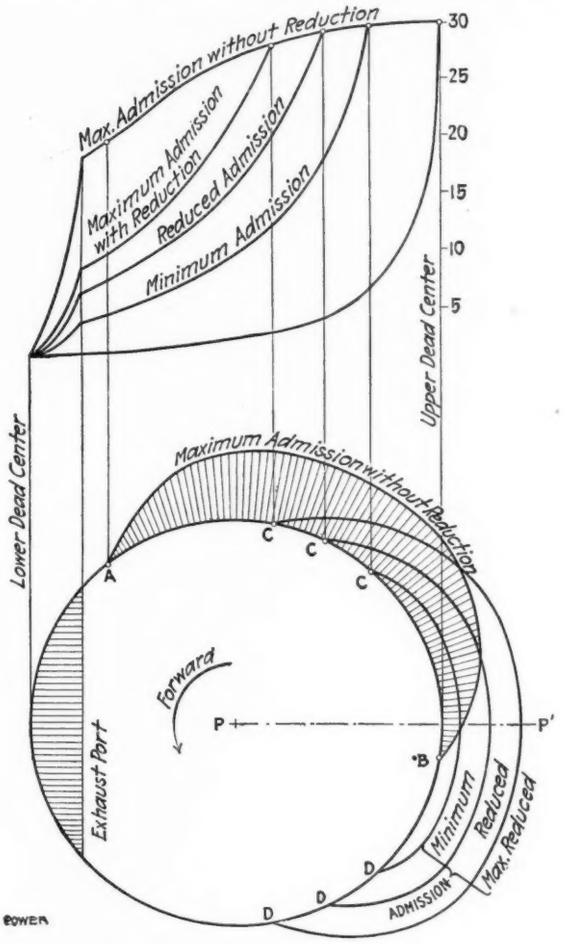


FIG. 6. DIAGRAM OF EVENTS DURING STARTING

the lever for regulating the deliveries of the fuel pumps, the starting monitor, the brake valve, the sander, the whistle connection and the various gages.

The starting preliminaries include the setting in motion of the auxiliary plant and the throwing in of the valve for the air used in starting the main engine. To get under way the air valve at the monitor is slowly opened. The air flows from the proper air reservoirs to the starting valves of the main engine, the air pressure

slowly rises and the engine begins to turn. The cutoff by the starting valve is gradually shortened, the pressure meanwhile rising. On attaining a speed of about six miles an hour the starting valves are cut out and the fuel valves brought into action. The locomotive is then in normal operation and the delivery of the pumps and the pressure of the injection air are regulated according to the service of the locomotive and its desired speed. To stop, the fuel valves are released from action and the brake is applied. Reversal is effected by the manipulation of a handwheel located in each operating room; a special stop preventing this while the fuel valves are cut in.

Trial trips were run with a view to observing the Diesel engine as applied to locomotive use and to note the action of starting and of the change from running by air to that of running as normally intended, and to test the reversing mechanism.

In Fig. 8 are shown reproductions of indicator diagrams taken during the runs.

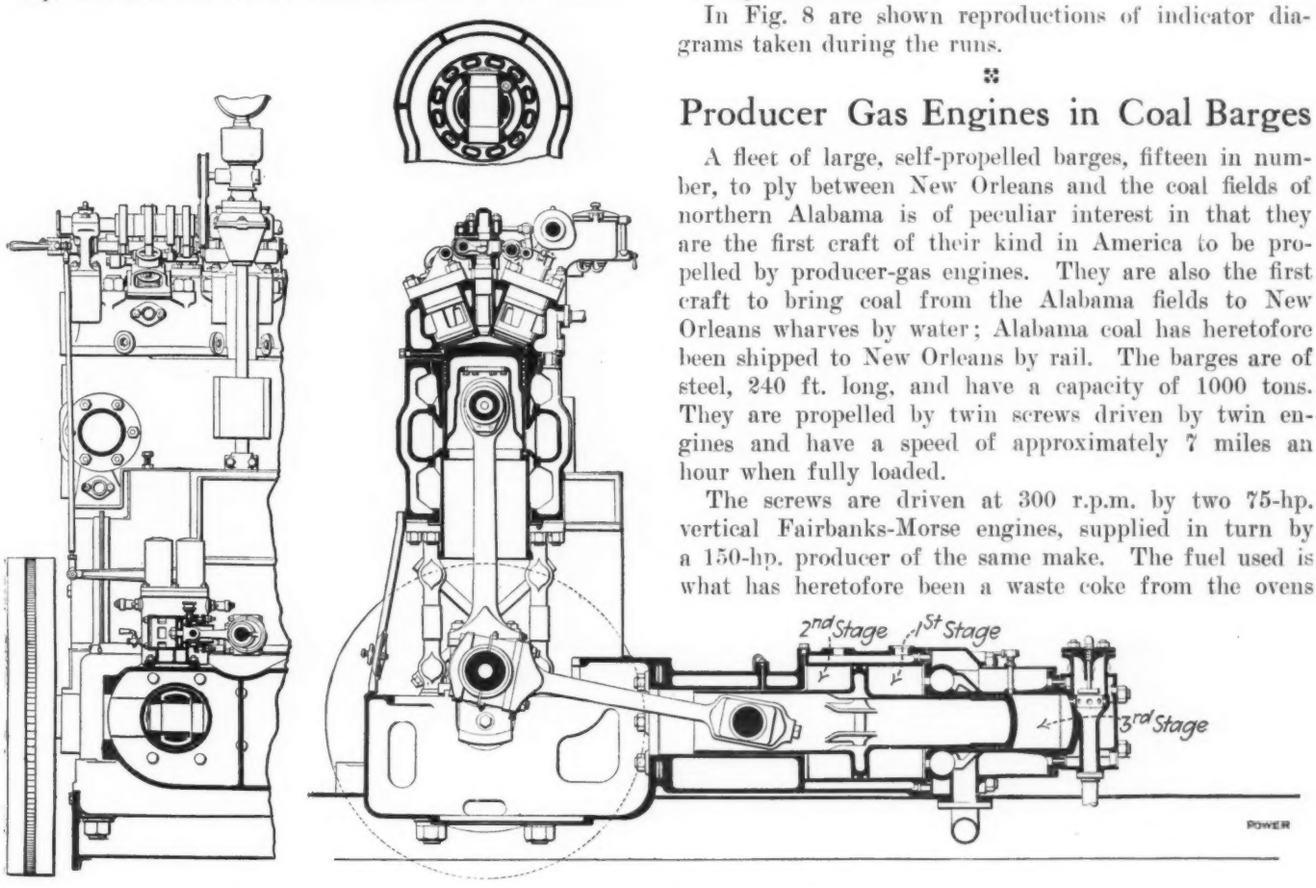


FIG. 7. ELEVATION AND SECTION THROUGH AUXILIARY ENGINE AND AIR COMPRESSOR

Producer Gas Engines in Coal Barges

A fleet of large, self-propelled barges, fifteen in number, to ply between New Orleans and the coal fields of northern Alabama is of peculiar interest in that they are the first craft of their kind in America to be propelled by producer-gas engines. They are also the first craft to bring coal from the Alabama fields to New Orleans wharves by water; Alabama coal has heretofore been shipped to New Orleans by rail. The barges are of steel, 240 ft. long, and have a capacity of 1000 tons. They are propelled by twin screws driven by twin engines and have a speed of approximately 7 miles an hour when fully loaded.

The screws are driven at 300 r.p.m. by two 75-hp. vertical Fairbanks-Morse engines, supplied in turn by a 150-hp. producer of the same make. The fuel used is what has heretofore been a waste coke from the ovens of the Birmingham District, and which consequently is secured at a very low price. This coke is practically pea size, and has a calorific value of about 11,000 B.t.u. Bunkers are provided to hold about 15 tons. Each producer is equipped with a scrubber, gas tank and tar extractor, and is fitted with a water bottom.

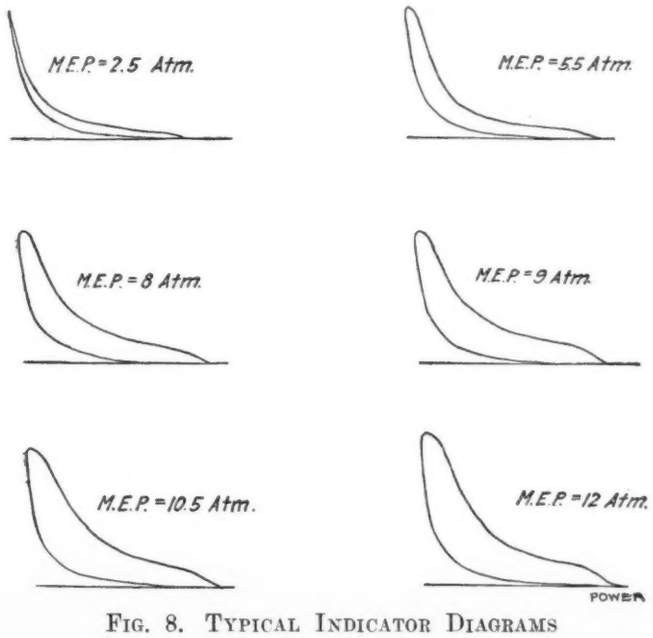


FIG. 8. TYPICAL INDICATOR DIAGRAMS

The auxiliary power equipment consists of a 9-hp. gasoline engine, which drives a centrifugal pump handling the ballast and bilge water, a blower, an air compressor and a 5½ kw. direct-current generator. Current is used for electric lights throughout the boat, fans in cabins and engine room, a 3200-cp. searchlight and a 5-hp. motor. The motor is for operating an anchor winch. The generator is so mounted that when the large engines are running it may be belt driven from one of them. A second 4-in. centrifugal pump is also installed, to be driven by one of the large engines through friction-wheel contact.

The barges will make the trip from the mine region to New Orleans in 72 hr., and with all fifteen vessels in service it is estimated that coal will be moved into New Orleans at the rate of 50,000 tons a month.

REFRIGERATION DEPARTMENT

Ammonia Condensers—II

By Fred. Ophüls

Double-Pipe Condensers

The condensers illustrated in Figs. 3 and 4* are not of the purely counter-current type for the reason that the flow of the ammonia through the condenser coils is perpendicular to the flow of the water over the outside. The requirements of counter-current flow are not only that the hot ammonia vapor is cooled by the water near the point where it leaves the condenser and that the liquid ammonia leaves at or near the point where the water comes on the condenser, but also that the current of ammonia flows parallel to the current of water and in opposite direction to it. While these types fulfill the first requirement they do not meet the latter. There is, however, an ammonia condenser built that is designed to meet both conditions; this is the double-pipe condenser.

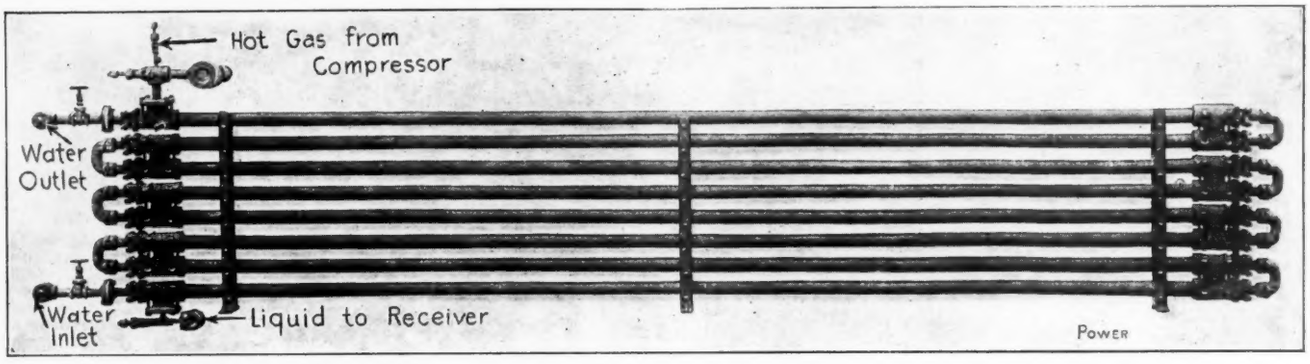


Fig. 7. Double-Pipe Ammonia Condenser

Figs. 7 and 8 show that the basis of construction of type (a) is the placing of a smaller pipe inside of a larger one. The condenser is generally made up of 1¼-in. and 2-in. pipes; the former pass through the latter and are fitted at their ends with return bends to afford a continuous passage for the water through them either from the bottom to the top pipe or vice versa. The 2-in. pipes, cut shorter than the 1¼-in. pipes, are also joined by return bends through the ends of which the 1¼ in. pipes pass, and the ammonia vapor is cooled and liquified in the annular space between the inside of the larger and the outside of the smaller pipes. In this design the ammonia is made to flow parallel and in opposite direction to the water, for the ammonia enters the annular space at the free end of the top pipe and the water enters the inside of the 1¼-in. pipe at the free end of the bottom pipe or vice versa.

In type (b) a double-size condenser is arranged with the water header and the ammonia-vapor and liquid header located at opposite ends of the condenser. The objection to this arrangement is that in alternate pipes the water and the ammonia flow in the same direction.

*See Sept. 2 issue, page 335.

Surface Condensers

For some time attempts have been made to imitate the standard construction of the surface steam condenser, but great difficulty was experienced in so designing this type for ammonia work as to prevent leakage of ammonia into the water. The main difficulty was found in keeping tight the joints between the straight tubes and the tube sheets on account of the variations in expansion and contraction.

The first successful design of what may be called a surface condenser for ammonia was constructed with spiral coils (type a) through which the cooling and condensing water flowed. Figs. 9 and 10 illustrate this type. It consists of a cast-iron or steel shell closed at both ends by dished heads. Within this shell are placed a number of closely wound spiral pipe coils, the top and bottom ends of which protrude through the respective heads and are each joined by means of manifolds. Where the ends of the pipe coils pass through the heads tight joints are made with the usual packed stuffing-boxes and glands.

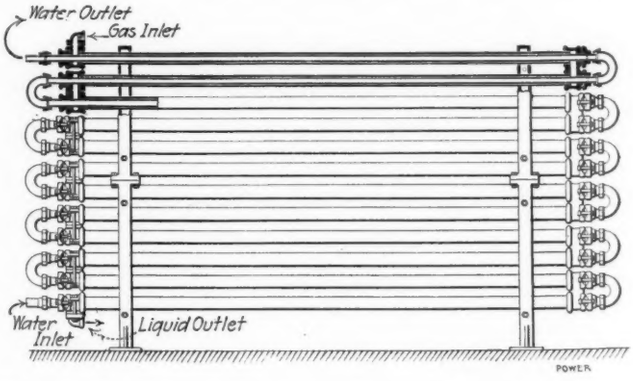


Fig. 8. Construction of the Double-Pipe Condenser

The ammonia vapor surrounds the pipe coils and enters near the top of the shell as shown. The liquid is drained off either at the bottom of the shell or else at the side of the lower head. The water enters the bottom coil

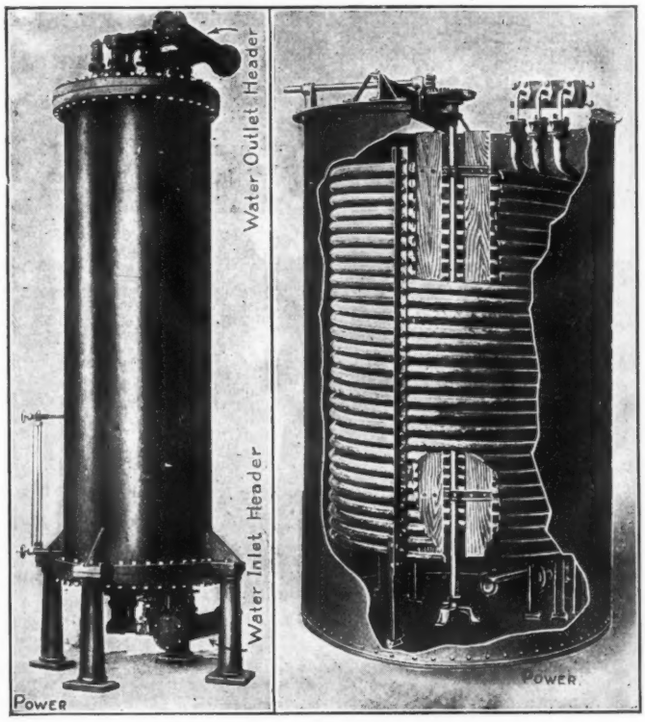


Fig. 9 Fig. 13

FIG. 9. SPIRAL-COIL TYPE SURFACE CONDENSER

FIG. 13. SUBMERGED CONDENSER WITH MECHANICAL WATER STIRRER

manifold and flows up through the pipe coils, leaving at the top. The flow of the vapor is perpendicular to the flow of the water, but the general direction of flow is opposite.

From the illustration, Fig. 11, of a straight-tube type of surface condenser, it appears that its construction is very similar to the standard surface steam condenser. The sketch is not intended to represent a particular design, but to give an idea of the general way in which such a condenser is arranged. The cooling and condensing water enters at the bottom of half the tubes and flows to the opposite head, returning through the remaining tubes to the bottom. The head where the cooling and condensing water enters and leaves is divided by a partition so that the incoming and outgoing water does not mix. In some designs a partition is used in the vapor space to cause a flow counter-current to that of the water, but in the case illustrated the partition is not used. The ammonia vapor enters at the top, and the liquid leaves at the bottom on the opposite side.

SUBMERGED CONDENSERS

When refrigerating and ice-making machines were first built the submerged condenser was used in almost all cases. These condensers are cheap in first cost and readily constructed. They do not give results which can be compared favorably with most of the other types.

Figs. 12 and 13 show the construction of submerged condensers with spiral coils. The ammonia flows through the coils, generally entering at the top, and the cooling and condensing water circulates in the surrounding tank. The arrangement of the vapor and liquid headers varies somewhat with the taste of the designer.

In some of the constructions the liquid is drained off at the bottom directly into the liquid receiver, as shown in Fig. 12. Sometimes the bottom ends of the coils are turned up inside the tank and the liquid headers located near the vapor header just outside of the tank, Fig. 13. The cooling and condensing water enters the tank at or near the bottom and leaves at the top, the inlet and outlet water connections being located at opposite sides of the tank.

On account of the poor circulation of the water the heat transmission coefficient of the cooling-pipe surface is low and the capacity of a certain size condenser is small in comparison to an atmospheric condenser contain-

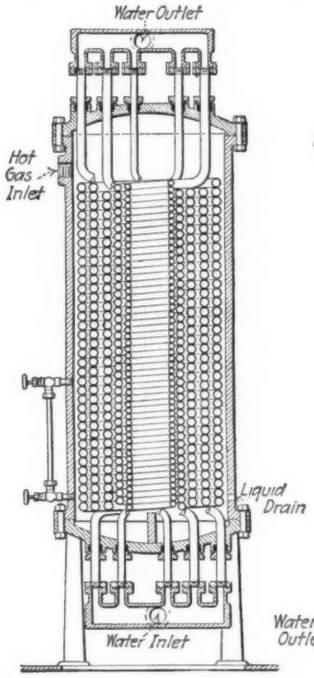


Fig. 10

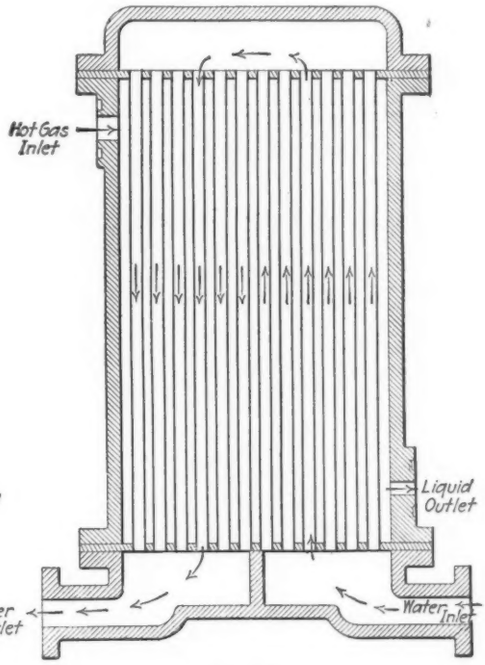


Fig. 11

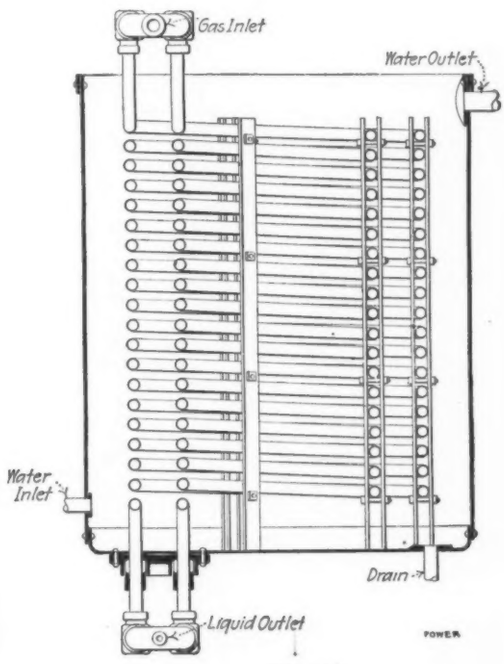


Fig. 12

FIG. 10. SECTIONAL VIEW, SHOWING ARRANGEMENT OF THE SPIRAL-COIL SURFACE TYPE. FIG. 11. STRAIGHT-TUBE SURFACE CONDENSER. FIG. 12. SPIRAL-COIL SUBMERGED CONDENSER

ing approximately the same area of condensing surface. To improve the efficiency of these condensers some have been designed with mechanical stirrers which consist of a number of paddles rotating about a vertical shaft placed in the center of the tank, as in Fig. 13. The paddles circulate the water in opposite direction to the flow of the ammonia through the coils. Sometimes the paddle blades are inclined at a slight angle to the vertical to give to the water an upward motion.

The straight-coil type illustrated in Fig. 14 consists of one or more vertical pipe stands made up of horizontal pipes either bent to close centers or else joined by means of return bends to afford a continuous passage for the ammonia through them. These coils are submerged in a

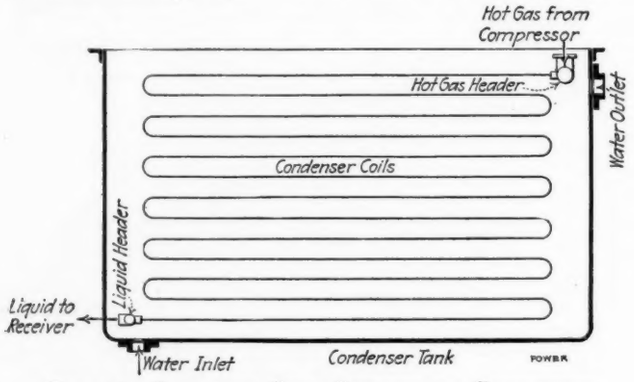


FIG. 14. STRAIGHT-COIL SUBMERGED CONDENSER

suitable rectangular tank and the vapor and liquid headers arranged somewhat as shown. The cooling water enters near the bottom of the tank at the end where the liquid ammonia leaves, and is drained off at the top of the other end, where the hot vapor enters. The disadvantage of this construction is that the cooling water has a tendency to short-circuit diagonally across the tank from the point where it enters to where it leaves, so that there are parts of the tank in which the water does not circulate properly.

Removing Ammonia Charge from Compression System

To remove the old charge of ammonia from the system, attach to the charging valve a standard ammonia drum on a platform scale by means of a ½-in. pipe about 10 ft. long. The drum should be so connected that the pipe nipple within the tank is turned up.

It is essential not to charge into a standard 100-lb. liquid drum more than 100 lb., and, for this reason, the drum should be placed on the scale and the weight noted from time to time while drawing off the ammonia. It is, of course, necessary to close the main liquid valve going to the ice-making or refrigerating system, so that the ammonia which is discharged from the condenser into the receiver can pass directly into the drum.

When it is not certain that the drum receiving the charge of ammonia is empty, and the net weight of the drum is not known, it may be assumed that the 100-lb. drum, when empty, does not weigh more than 200 lb., so that when it is fully charged the scale should show not to exceed 300 lb.

In drawing off the charge of ammonia, the system is operated just as if pumping out the low-pressure side of the plant, and if there is no liquid-level gage on the receiver, the only way to tell when the system is empty of liquid is to find out when the drum on the scale shows no further increase in weight.

Care should be exercised to make sure that the expansion side of the plant is fully pumped out before starting to break any joints, and depending upon the size of the plant and its arrangement, it may be necessary to pump below atmospheric pressure five or six times, before the ammonia is all drawn out. When this has been done, allow the system to stand for two or three hours and see whether the pressure on the suction gage does not rise. If it does not, the system is empty.

While drawing off the charge of ammonia it would be advisable to reduce the amount of water flowing over the ammonia condenser, so that the discharge pressure will be high enough to force the liquid into the drum. By referring to a table giving the properties of ammonia corresponding pressures and temperatures may be obtained. For example, suppose that the room in which the charging valve is located is at 95 deg., F., at the time the charge of ammonia is being removed from the system. The ammonia pressure corresponding to this temperature would be 184 lb. gage, so that the ammonia may freely flow into the drum. The condenser pressure should be at least 10 lb. higher than this pressure.

The principal things to look out for, then, are to see that not too much ammonia is charged into the drum and that the condenser pressure is at least 10 lb. higher than the pressure corresponding to the temperature of the room in which the drum is located. The ammonia vapor left in the high-pressure side of the plant, after the liquid is drawn off, cannot be recovered. It must either be blown out, or else pumped over into the low-pressure side after the latter has been repaired.

Turbine Exhaust for Ice Making

The engine room of the new power plant of the Kentucky Traction & Terminal Co., at Lexington, has an ice plant quite different from those ordinarily met. Two 75-hp. Terry turbines, direct connected to two 8000-gal. centrifugal water pumps for pumping cooling water from the spray pond for the steam and ammonia condensers, furnish exhaust steam for a Corbondale ice plant.

The liquid ammonia from the condenser passes through a 1½-in. pipe line a distance of more than 500 ft. to the building containing the ice tanks, where it is expanded through the coils. The expanded vapor from the expansion coils, after passing through the coils in the distilled-water storage tanks, returns through a 6-in. line to the absorber on the roof of the power house.

The exhaust from one of the turbines is sufficient for the generator under ordinary circumstances. During the summer months, with condensing water at 95 deg. F., the increased steam consumption due to back pressure on the turbine does not exceed 20 lb. per hr. per ton of ice—about one-third that required for a compound condensing compression machine. During the winter months the excess consumption is but three pounds per hour per ton of ice. As the condensate from the turbines is free from oil, the ice is of excellent quality. The plant was erected under the supervision of Sargent & Lundy, consulting engineers, of Chicago.

EDITORIALS

The Diesel Locomotive

After several years of experimentation, during which many obstacles were encountered and overcome, a Diesel locomotive has been completed and put in service.

Referring to the description on page 470, one is first impressed with the apparent complexity of the arrangement as compared with the familiar steam locomotive. Flexibility of operation has, of course, been one of the big problems in working out the design, and this has been obtained only by the employment of an auxiliary plant of about one-fourth the capacity of the main engines, for starting and accelerating up to a speed of five or six miles per hour. This has added greatly to the weight per horsepower.

Conceding that this is a first attempt and that time will undoubtedly bring improvements with corresponding simplification, still it is doubtful if the Diesel will ever attain that degree of flexibility possible with the steam locomotive.

The gasoline engine has reached as high a stage of development in its line as the Diesel engine, yet it has proved unsuitable for driving interurban cars direct; hence the gasoline-electric drive was resorted to and has given excellent satisfaction on many roads. It would seem that the field for the Diesel engine for locomotion might lie along similar lines.

Figures are not available at this time as to the economic performance of this locomotive, and until they can be compared with those of a steam locomotive running under similar conditions, the commercial value of the former must remain an unknown factor.

⁂

Standard Pipe Flanges

The committees of the several engineering societies responsible for the 1912 United States Standard for Pipe Flanges and the manufacturers who took exceptions thereto and produced the Manufacturers' Standard, have gotten together and effected a compromise. While this compromise standard is not so good as could have been made, starting with a clear field, it is probably the best which could be done under the existing circumstances, taking into account the interests of the manufacturers and the protection of their large investment in patterns and stock of the prevailing dimensions.

The compromise was effected by the adoption by the manufacturers of the number of bolts, diameter of bolt circle and thickness of flange advocated by the committees, retaining, however, their own face-to-face and face-to-center dimensions, except as they were modified to meet the other changes. This brings about the desired uniformity in the flanges themselves, and sacrifices only the interchangeability which the 1912 U. S. Standard sought, in prescribing the same face-to-face and face-to-center dimension for fittings for similar sizes of pipe. This feature was of less practical importance than it appeared, and upon the comparatively rare occasions in which fittings in a pipe line are removed to be replaced by others of the same size, as a cross for a tee, the user can better afford to pay the slight charge for a special fitting than the whole trade to go through the convulsion of getting them all alike.

We are glad to see the matter amicably settled. Manufacturers representing 85 per cent. of the output have come to an agreement with the committee of the American Society of Mechanical Engineers, and, although the committee of the National Association of Master Steam and Hot Water Fitters has not yet accepted the compromise, it is practically certain that the double standard, which for two years or more has threatened, will be avoided, and that we shall settle down to one American standard, acceptable alike to the manufacturer and user.

To meet the wishes of the waterworks engineers the dimensions for standard fittings have been given up to 100 in. in diameter instead of to 48 only, as before, and of the extra-heavy fitting up to 48 in. instead of only to 24 in. as before.

⁂

What Is the Use?

This expression has been used, probably, by every reader, as a reason why some piece of work should or should not be done, or why some particular effort should, or should not, be made. It is a natural and sensible question to ask under some circumstances, but shows lack of forethought in others.

If a new power-plant apparatus is suggested the engineer wants to know "what is the use" of putting it in. Will it assist in making a better showing in the plant economy, or will it fail to assist in the operation? If the apparatus is installed because one is used in another plant where operating conditions are radically different and if it cannot produce results commensurate with the cost, then it is of no use, from a monetary standpoint.

All too often, however, the expression "what is the use?" is the result of indolence on the part of the engineer. The boiler room is dirty and untidy; tools are scattered here and there, coal covers the floor, the ashpit is nearly filled with ashes and the boiler setting is badly cracked. Ask the attendant why these conditions are not changed and the answer will doubtless be, "What is the use? I will get my week's pay just the same without doing the extra work."

If the fireman is contented to remain in the same position, year after year, without advancement, working for less than two dollars a day, in some cases working twelve-hour shifts, there is no use in trying to better his own or the condition of the plant, if he can manage to hold down the job.

An engine knocks, requires valve adjusting, is dirty, but still manages to turn over during the working hours, regardless of the amount of steam consumed. Ask the engineer why he does not attend to the engine and the reply will be, "What is the use, the engine runs, doesn't it, what more do you want?"

From the standpoint of such an engineer, nothing more can be expected, what is the use? Contented to draw his pay, content with allowing the engine to run itself, such a man will spend his time in a battered, makeshift chair, content with his surroundings and with himself.

Ambition to run a better and larger steam plant possesses the average young engineer. He has sense enough to know that there will be but slight possibilities of his assuming control of larger plants unless he prepares himself for the position. *What is the use* of idling away days by not preparing to make use of opportunities when they appear? *What is the use of* grumbling at the apparent luck of others who reach the better and higher positions, when no effort has been made on the part of the disgruntled one to fit himself to fill the place? *What is the use* of being discontented with existing conditions, when no real effort has been made to change them?

The men who occupy the desirable engineering positions do not do so by chance, at least not often and then not for long. The men who operate the small undesirable steam plants do not do so because fortune has not favored them; not as a rule. Both classes of engineers occupy the position for which they are fitted.

If a man has no desire to advance to a better plant, earn more money and get more out of life, there *is no use* in his doing anything else but hold down the old job with the dirty boiler room and thumping engine. But what kind of an engineer is he?

The Thief Discovered

For a long time we have been receiving complaints that remittances sent by our subscribers were unacknowledged, and that in many cases a second claim was made for money already sent.

At last the culprit has been found in one Charles Moscovitz, a clerk in the New York City General Post Office, who, at the time of his arrest by post-office inspectors, had thirteen letters addressed to POWER concealed in his right sock. Moscovitz is alleged to have said that "he had no excuse to offer and that he was prepared to take his medicine." The federal authorities believe that his stealings cover a period of nearly nine years.

Between Jan. 1 and Sept. 20 of this year there were 658 letters containing remittances which failed to reach this office. This is over three letters for each working day, entailing a loss of between one hundred and fifty and two hundred dollars a month.

Our greatest concern, however, has been for the trouble, dissatisfaction and annoyance which has been occasioned to our subscribers. Our wish is, of course, that every man who pays for the paper should get it regularly. Our strength is in our circulation. When you send money by mail, make it as little apparent as possible that it is money; remember when and where and at what time you mailed it and the sort of envelope used, and if you don't get an acknowledgment or do get another bill, don't cuss POWER, let us know at once.

Your bookkeeper will probably be glad to give you a check in exchange for your cash, and if a Moscovitz gets that he cannot use it, while its nonreturn through the bank will show that we did not get and use it.

The New Man

Any engineer who has had the experience knows how unpleasant it is to be put in charge of a plant without having time to become acquainted with the peculiarities of the place before his predecessor quit the job. Usually it is such a disagreeable situation to find oneself in that the victim will, if he is honest, resolve never to leave a job until he has "broken in" his successor, if possible.

Power plants are somewhat like men—no two are alike. Each has its characteristics, individually trivial, but the comulative effect of them is such as to warrant individual consideration to avoid inconveniences. Minor troubles are often discouraging to a new man, although he should not be too easily disheartened. But if these small troubles which worry and often seriously confuse nearly every man, can be avoided by having his predecessor remain with him for a week or two, why not have him there?

Take a man who is familiar with central-station work or the plants of manufactories only and place him in charge of a large office-building or department-store plant. Suppose that man were you? Would you not do your work better, would you not feel more favorably inclined toward the management if your predecessor were allowed to remain with you for a while? Of course you would.

The management is likely to fail to understand this as well as the engineers do and hence they should be informed of the need of getting the new man on the job a week or so before the old one leaves.

Four hundred million dollars a year can profitably be used in the development of electrical industries in the United States during the next five years, says Frank A. Vanderlip, president of the National City Bank of New York. Such figures are staggering and one might be inclined to accuse Mr. Vanderlip of being over-optimistic. In support of his statement, however, he cites statistics to show that the investment in central-station properties increased during the period 1902 to 1907 from five hundred million to one billion dollars. Although the figures for the last five years, 1907 to 1913, are not complete, they indicate a present investment of over two billion. At this rate, Mr. Vanderlip's prophecy seems reasonable.

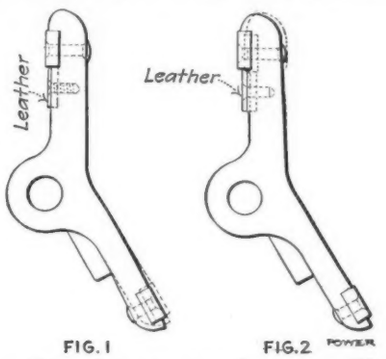
Whether the rate of increase has reached a maximum is hard to tell, but it is certain that the field for electricity in industrial lines is continually broadening and the electrification of railroads is progressing, slowly perhaps, but surely. Moreover, electricity is no longer regarded by the public in the light of an experiment; hence such investments should attract capital, especially in view of the guarantec against so called "high finance," now afforded by public-service commission supervision.

The Central Union of German manufacturers has adopted a resolution declaring that the great majority of German manufacturers are absolutely opposed to participating in the Panama-Pacific Exposition, and thanking the German government for its attitude. The protestations that the restrictions placed by the United States upon foreign products make it impossible for German industry to obtain any advantages by participating in the San Francisco Fair, would have been just as true of Chicago or St. Louis, where Germany had extensive and creditable displays.

READERS WITH SOMETHING TO SAY

Experience with Old Brown Engine

Like many engineers, I eventually had charge of an old-type Brown engine, a four-valve gridiron-valve engine having the valves and governor operated from a layshaft running under the frame, and connected to the main shaft by bevel gears. Small eccentrics on the side shafts are connected to levers which engage the latches that lift the valve. As with other four-valve engines of the re-



SHOWING HOW BADLY THE LATCHES WERE BENT

lease gear, these latch blocks must be kept in good condition to insure good running and economical operation.

Although this engine was not in bad shape, some of the pins were badly worn. The indicator was put on the engine, and some peculiar diagrams taken. Then the pins were turned around and as much lost motion taken up as possible. The indicator cards improved, but showed a greater mean effective pressure on one end of the cylinder than on the other. This was a puzzle, as the valves were carefully set according to the shop marks. I noticed that one of the latches seemed to be closer to the tripping lever than the other. Thinking that one of the tripping levers had been set farther forward on the rockshaft than the other, I loosened it to set it back, and thus equalize the cutoff. To my surprise the rockshaft had been "spotted" for the setscrew, and the lever was set at the shop mark. Before taking out the rockshaft, I concluded to put on new latch blocks, and so removed both latches. By chance I got them side by side edgewise, and then I noticed that there was a difference of ⅛ in. in their angles.

The end of the latch, Fig. 1, was sprung $\frac{1}{16}$ in., as the dotted line indicates, while the latch on the other end resembled Fig. 2. This was the reason why the cutoffs could not be equalized. It could be done, but the extra shims required on the tripping levers were likely to have the effect of changing the position of the governor, and possibly cause unsteady operation of the engine. The latches were bent by holding them over the edge of an anvil while riveting on the case-hardened blocks.

To see what effect changing the thickness of the plates on the ends of the latches would have on this type of an engine, I experimented by putting tin shims on the tripping levers of the rockshaft. Fig. 3 shows a diagram from each end of the cylinder with a shim $\frac{3}{64}$ in. thick added to the tripping lever on the crank end. Fig. 4 shows a $\frac{1}{32}$-in. shim added to the head-end tripping lever, while Fig. 5 is a normal diagram.

R. A. CULTRA.

Cambridge, Mass.

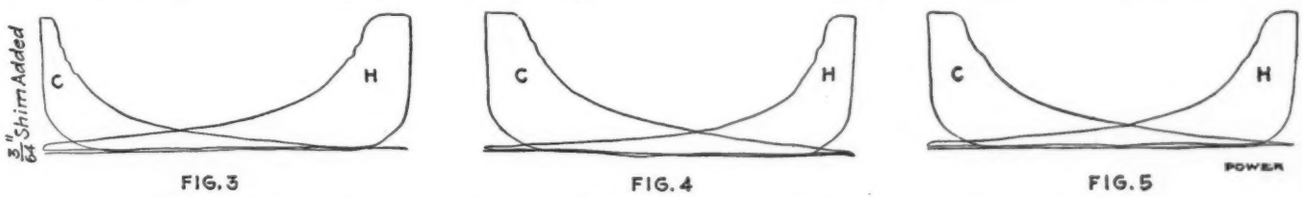
Air-Receiver Inspection Needed

Much ado has been made, especially in some of the Central states, over the criminal carelessness of engineers employed at mines. That compressed-air plants, in many instances, are operated under dangerous conditions is known no better than by some of the engineers themselves. But, these engineers may be working under orders which to disobey would mean the loss of their jobs, and many an engineer with a small salary and a large family would take a chance on his life as soon as take a chance on his job. But if any plant so operated be put under state inspection and the engineer in charge given to understand that any neglect or carelessness will mean dismissal, then orders will be obeyed and conditions will become safer.

That there are more explosions of air receivers than of boilers according to the number of each in use is a proof of what inspection will do toward rendering a plant safer, for many air receivers are not subjected to state or insurance inspection.

If, too, an explosion occurs in a plant not under state or insurance inspection and operated by a non-licensed man, then no one competent is compelled to make a thorough investigation and "the can is usually tied to the wrong man" while the plant still continues to be operated in the same dangerous manner. If, by chance, the blame is put on the right party he simply looks up another job and goes on as before.

But, let an explosion take place in a plant under state inspection and operated by licensed engineers, then, a



BROWN ENGINE DIAGRAMS, SHOWING EFFECT OF PUTTING SHIMS IN TRIPPING LEVERS

thorough investigation is made by a competent inspector, who will find the right man, have him discharged and his license revoked, which will be a guarantee that he will not have the opportunity to do the same thing again.

The writer has been employed as operating engineer in eight different compressed-air plants, six of which were operated under dangerous conditions.

The following observations were made concerning those operated under state inspection and those that were not:

Total number of air compressors operated with receiver connections	44
Total number (including receivers) under state inspection	0
Total number (including receivers) under insurance inspection	0
Total number explosions	4
Total number men discharged on account of explosions	0
Total number licenses revoked	0

Boilers operated in connection with these eight plants as follows:

Total number operated	39
Total number under state and insurance inspection	22
Total number under state inspection only	26
Total number under insurance only	2
Total number under neither state nor insurance inspection	11
Total number of explosions	1
Total number men discharged on account of explosion	1
Total number licenses revoked	1

The above table, though somewhat meager, seems to me to substantiate the theory that state inspection will bring about the safest possible conditions for boilers, air receivers, etc., while insurance inspection, though more limited in its authority, will do much toward lessening the number of explosions.

R. S. HART.

Stockett, Mont.

Nozzles for Washing Boilers

In ordinary washing of return-tubular boilers it is customary to depend upon the impingment of a stream of water from the nozzle of a hose introduced through handholes or manholes in the boiler. The process is anything but effective in removal of scale and mud which might be loosened and washed from the surfaces of the

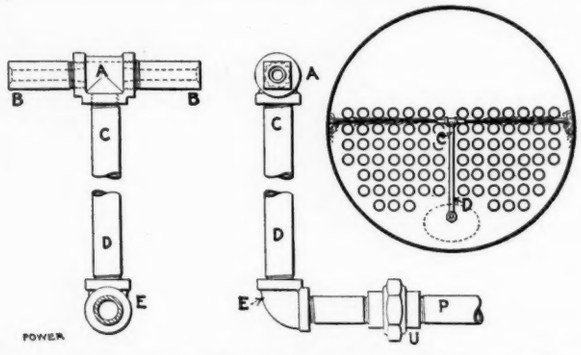


FIG. 1. NOZZLES FOR WASHING BOILER TUBES AND SHELL

tubes and shell if subjected to the erosive action of a stream of water of high velocity, directed normally to the tube and shell surfaces. The use of a bent pipe for directing the stream of water to various parts of the boiler at best is suitable for reaching only portions of the tubes and shell surfaces and the upper and lower surfaces of the tubes receive little or no benefit.

For overcoming these difficulties I have constructed nozzles such as shown in the accompanying sketches and by their use, supplied with water at 100 to 125 lb. pressure from a house-tank pump, have been enabled during the past two years to keep the tube and shell surfaces of my boilers clean with noticeable improvement of boiler economy and steaming capacity.

Referring to Fig. 1, *A* is a ¾-in. tee into which are screwed nozzles *B* and *B*, which are made from 1-in. square steel, each nozzle being bored its full length with a hole ⅜ in. diameter counterbored at each end, as shown by the dotted lines. The pipe *CD* is connected to *A* and is provided at its lower end with an elbow *E*, short nipple

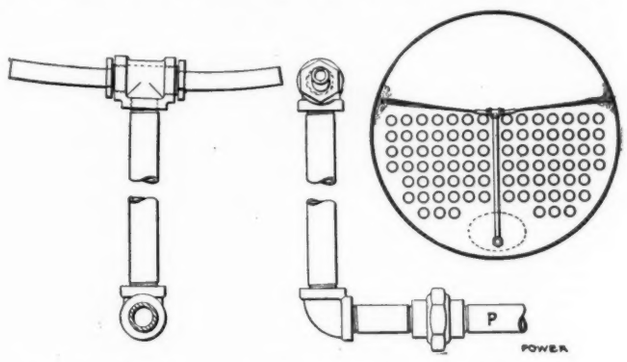


FIG. 2. NOZZLES FOR WASHING BOILER ABOVE TUBES

and brass ground spanner union for coupling the nozzle pipe to a reach pipe *P*.

The nozzle pipe *CD* being detached from *P* is readily introduced through a manhole or handhole near the bottom of the boiler and the nozzle end raised up between the tubes.

By then turning the nozzle pipe 90 deg., as shown in the cross-sectional view of the boiler, it may be supported on the middle pair of a horizontal row of tubes, as shown in Fig. 1, at a height depending on the length employed for the nozzle pipe *CD*, and by means of the union *U* connected to a reach pipe supplied with water through a high-pressure hose connected to a pump or other source of high-pressure water supply. When thus connected, the water supply being turned on, the nozzle pipe by means of the reach pipe is moved from one end of the boiler to the other, while powerful jets of water are projected between the tubes, impinging on the sides of the shell and the upper and lower sides of the tubes, as illustrated in Fig. 1.

The object of making the nozzles *B* of square steel is that they may act as scrapers for removal of any deposit formed on the upper or lower sides of the tubes between which the nozzles are passed.

For washing the tubes of our 66-in. boilers we use three different lengths of nozzle pipes like *CD*, and for washing the shell above the tubes use nozzles formed of bent pipe, as shown in Fig. 2 with duplicate coupling fittings for attaching the nozzle pipes interchangeably to the reach pipe *P*.

Boiler-washing nozzles of the kind described can be made up of materials to be found in most any power plant at only a nominal cost of construction and when used at proper intervals with water at high pressure will be found to give satisfactory results.

The efficiency of these nozzles in cleaning boilers, when used with high pressure of water, is remarkable.

A. E. BORNMANN.

New York City.

QUESTIONS BEFORE THE HOUSE

Soda-Ash for Boiler Waters

A very serious and readily evident error appears in my article under the above head in the Sept. 16 issue, page 412.

It is stated that 275.13 lb. of soda ash is needed to make a solution of 3 per cent. normal alkalinity with 5000 lb. of water, which is the amount that a 100-hp. horizontal tubular boiler will contain when full to normal water level. This amount is greatly excessive, owing to the fact that 55 grams is given as the amount of soda-ash necessary to produce a 3 per cent. normal solution with 1 liter of water. A normal solution contains 53 grams per liter; a 3 per cent. normal solution will contain

$$53 \times 0.03 = 1.59 \textit{ grams per liter}$$

and a gallon of 3 per cent. normal solution will contain

$$1.59 \textit{ gr.} \times 3.79 \textit{ liters} = 6.02 \textit{ gr.}$$

A 100-hp. horizontal tubular boiler containing 5000 lb. of water will require

$$600.24 \textit{ gal.} \times 6.02 = 3613.44 \textit{ gr.,} \text{ or } 7.97\text{— } lb.$$

of soda ash to bring it up to 3 per cent. normal alkalinity.

It is unfortunate that the error occurred, but as it is so evident, it is hoped that all who read the article immediately discovered it.

CHARLES H. BROMLEY.

New York City.

Power-Plant Vibration

The article by F. H. Davies on the above subject in the Aug. 12 issue of POWER prompts me to write the following:

Several years ago an engine was installed in one of the scientific bureaus in Washington. The upper floors of the building were occupied by instrument-testing laboratories, the work in which would be disturbed by excessive vibration. For this reason the engine foundation was built entirely isolated from the engine-room floor, a space of about ⅛ in. being left between them.

The soil in this vicinity is dry and of a stable character and will not conduct vibrations to any great extent. As shown by the sketch there is a sub-basement under the engine-room floor, and it was thought that dirt falling into the ⅛-in. insulating space would fall through into the basement. For some reason, however, the floor of the foundation seemed to spread gradually, until in time the insulating space was entirely closed in places, with a consequent increase in the vibration transmitted to the building.

Recently another engine was installed in the same building and a modification of the method first used with satisfactory results. Fig. 1 shows the general layout of the foundation with relation to the surrounding floors. Fig. 2 is intended to show more clearly the method used to provide a cover to the 2½-in. insulating space. A cover was deemed advisable for this space to prevent a possible accident to persons walking around the engine. Strap irons were fastened to the floor and foundation in the manner illustrated, the lugs and bolts being imbedded in the concrete as it was poured into the forms. On the

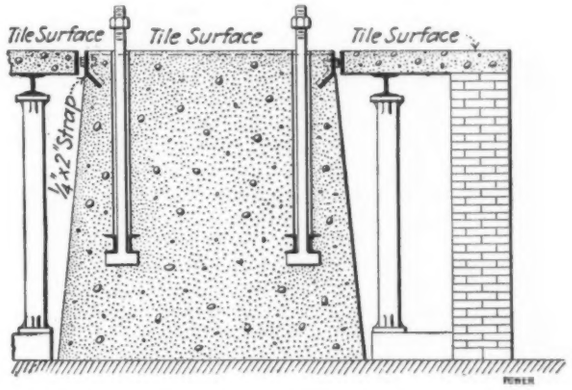


FIG. 1. FOUNDATION AS FIRST DESIGNED

foundation side the bolts fastening the straps to the imbedded lugs, were placed so that a ¼x2¼-in. strap iron laying on the bolt heads would level up the insulating space. The strap iron is a little less in width than the space in which it lies. This arrangement effectually prevents the transmission of vibration from the engine to the

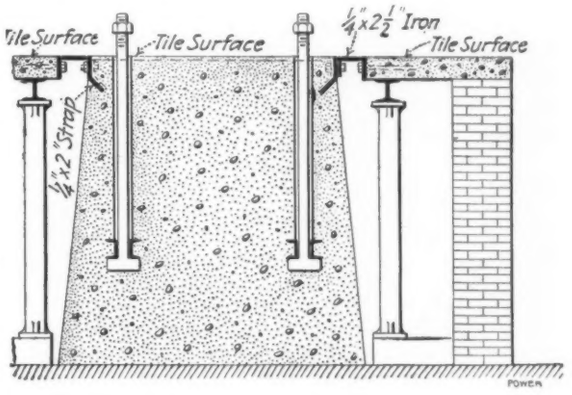


FIG. 2. MODIFICATION OF FIRST METHOD OF JOINING FLOOR TO FOUNDATION

floor and there is no foot trap around the engine to cause an accident.

H. G. GIBSON.

Washington, D. C.

Mr. Davies' article was read with interest, and it is hoped that it may prompt others to contribute to the literature on the subject. Vibrations in plants of hotels, office buildings, apartments, etc., is often difficult of elimination.

H. C. MARKUS.

Cleveland, Ohio.

INQUIRIES OF GENERAL INTEREST

Running Without Riding Cutoff—How could an engine be kept running temporarily if the riding cutoff gave out?

R. B.

In an ordinary Meyer riding-cutoff valve gear, by removing the cutoff valve from the steam chest, the distribution of steam could be effected by the main valve working as an ordinary slide valve, cutting off at the longest distance the steam would be admitted in ordinary operation. If the cutoff valve of the engine were operated direct by the governor, it would be necessary to control the speed of the engine by the hand throttle valve or by a throttling governor.

Effect of Advancing Eccentric—What would happen if the eccentric of a Corliss engine were advanced 45 deg. beyond the right position?

R. B.

The events, as admission, release and closure of the exhaust, would occur one-eighth of a revolution earlier. Admission would create so much back pressure before completion of the return stroke, opening of the exhaust would occur so soon after cutoff and compression of exhaust would begin so soon in the return stroke, from early closure of the exhaust, as to leave the engine capable of developing very little, if any, power.

Preventing Boiler Corrosion—When installing a new boiler can graphite or anything else be used to prevent corroding and pitting and keep the plates and tubes tight and free from rust?

B. R.

It would be best to give the inside of the shell and water side of the tubes a thorough coat of graphite paint when the boiler is made, before the tubes are set in the boiler. If the boiler is already constructed, paint all interior surfaces that can be reached and use sufficient graphite introduced with the feed water to form a good coating of graphite. It will hinder corrosion and prevent adhesion of scale.

Moisture in Oil-Fuel Burning—In conducting tests of our oil-fuel-burning boiler we have obtained results that vary perceptibly while the conditions of boiler, burner, etc., have been uniform. Atmospheric conditions have varied from dry to humid days. Has humidity any effect on boiler efficiency?

L. B. D.

Yes, during the oil-fuel-burning tests conducted by the Bureau of Steam Engineering of the navy it was found that a decrease in efficiency was produced by humidity, due to two causes: To the displacement of an amount of oxygen in a given volume of air by the moisture in the air, which requires an excess in volume of air for completing combustion, with consequent loss of heat in the stack; to the decreased rapidity of diffusion of the combustible gases with oxygen due to the presence of inert moisture.

Difference of Boiler Pressures—When two boilers, say one of 250- and one of 200-b.hp. capacity, are connected to the same steam line, what can cause one to show a higher pressure than the other?

F. H. K.

When for any reason either of them generates steam faster than it can be discharged into the steam line, then the pressure will rise in that boiler and faster than in the other, just as might happen if one boiler had its main stop valve partly closed. The same relative conditions might exist from the throttling action of the steam-pipe connections of one boiler being different from the other, and, as the relative throttling action varies for different rates of steaming and different discharging pressures, the pressures in two boilers connected to the same steam pipe are seldom absolutely the same, and their difference is constantly changing with the variations in intensities of their furnace fires.

Air Receiver Pound—What may be the cause of a pound in the receiver of an air compressor and how may it be stopped?

F. B.

The best way to trace the cause of the noise is to run the compressor only just fast enough for the hammering to take place. Then observe whether it may not be due to the noise of sudden seating of the check valve being conveyed to the receiver. A larger check valve might remedy the trouble, or a muffler placed between the check valve and receiver would probably prevent the noise being carried to the receiver. Such a muffler could be a cylinder of cast iron of about three times the diameter of the air pipe and about four times as long as its own diameter, divided by partitions into about five compartments with each partition cut out in the center by a hole the size of the main air pipe.

Pump Would Not Work—Can a pump with a 4-in. diameter steam cylinder and 3-in. diameter water cylinder deliver water into a boiler 20 ft. above it carrying a pressure of 100-lb. gage?

C. A. R.

The pump has to overcome the pressure due to 20 ft. head of water in addition to the boiler pressure. As each foot of head would create 0.433 lb. the pressure due to 20-ft. head would be

$$0.433 \times 20 = 8.66 \text{ lb. per sq.in.}$$

The pressure from the boiler being 100 lb., the total to be overcome by the pump would be

$$100 + 8.66 = 108.66 \text{ lb. per sq.in.}$$

The pressure acting in the steam cylinder would be its area in square inches, multiplied by 100 lb., i.e.,

$$12.566 \text{ sq.in.} \times 100 = 1256.6 \text{ sq.in.},$$

and as a 3-in. diameter water piston has an area of 7.0686 sq.in., neglecting friction, the resistance to motion of the water piston would be

$$108.66 \times 7.0686 = 768.074076 \text{ lb.}$$

The mechanical efficiency of the pump would have to be

$$\frac{768}{1256} = 61 \text{ per cent.}$$

As this efficiency for small pumps is rarely above 50 per cent., it is not probable that a boiler-feed pump would operate under the conditions stated.

Determining Heater Size—How does one arrive at the size of open feed-water heater required under given conditions?

F. E. B.

The proportions will vary depending on numerous conditions such as the character of the water, the arrangement of the trays, etc., but generally the size of the shell for a cylindrical heater should be approximately as follows:

$$A = \frac{H}{aL}$$

or

$$L = \frac{H}{aA}$$

in which

A = Sectional area of shell, square feet.;
L = Length of shell, feet;
H = Water to be heated per hour divided by steam used per horsepower per hour by the engine, pounds;
a = Constant depending on the kind of water—very muddy, 2.15; slightly muddy, 6; clear, 8.

Some modification in the pan or tray surface will be necessary according to the quality of the water, but in relation to mud- and scale-making ingredients, the surface in square feet for each 1000 lb. of water heated per hour may be taken as follows:

For the vertical type of heater:	
Very bad water	8.5
Medium muddy water	6
Clear and little scale	2
For the horizontal type of heater:	
Very bad water	9.1
Medium muddy water	6.5
Clear and little scale	2.2

Between rectangular pans the space should be not less than one-tenth their width, or for round pans one-quarter their diameter, and about a quarter of the total depth should be left for a storage and settling chamber.

ENGINEERS' STUDY COURSE

Boiler Efficiency—II

Before starting a test all instruments and weighing or measuring apparatus should be examined and put in good order and, where deemed necessary, they should be tested for accuracy. If possible, the blowoff and other water connections that can be dispensed with temporarily, such as an extra feed pipe, should be disconnected and sealed with blank flanges. This is to eliminate the danger of error due to water leaking out without being evaporated. The boiler should be examined both outside and in and a full memorandum of its condition during the test, as indicated by this preliminary examination, should be included in the report. This may be of value in explaining why the results secured are good, bad or indifferent, as the case may be. If the test is for the purpose of ascertaining the highest obtainable capacity or efficiency, the boiler, furnace and setting should be put into the best possible condition.

Duration of Test

The necessary length of the test will depend on its purpose and, somewhat, on local conditions. The greater the duration the less will be the effect of the errors that occur at the beginning and ending. Where the test is run under actual working conditions a duration of 24 hr. yields data on all conditions of load and operation. However, it is not always possible or convenient to conduct a test of that length and, hence, a shorter one is often made to suffice. One of 8 hr. is about as short as is safe if any dependence is to be put upon it; a 10-hr. one is better.

Starting and Stopping Test

Unless proper care is employed errors are likely to occur at the beginning and ending of a test. Effort should be made to have conditions at the start and the finish as nearly the same as possible; the steam pressure and water level, also, the size and condition of the fire should be as nearly equal as possible.

The code of the American Society of Mechanical Engineers outlines two methods of starting and stopping. One is called the "standard" method and the other, the "alternate" method. The first mentioned one consists of drawing the fire just before the start and building a new one on the clean grates, dating the start from the time a new fire is lit.

At the end the fire is burned thin and drawn, the finish being dated at that time. This method is open to criticism as there is considerable chance for error, due to the boiler being cooled when the fire is drawn at the start and finish. In addition, this method is considerably less convenient than the alternate method. The latter is as follows:

See that the boiler has been thoroughly heated by a preliminary run of suitable length at the working pressure. Burn the fire low and clean it well. Then make an estimate of the thickness and condition of the fire and make a memorandum of this. Note the time and record this as the starting time of the test and, then, proceed with periodic observation of the various pressures, temperatures, etc. Stoke the fire with coal that has been weighed and keep a record of the amount used. In the same way, keep a record of the feed water pumped, starting with the time that is recorded as the beginning of the test.

As soon as the test is started, clean out the ashpit thoroughly and throw away the ashes thus collected as they are not to be entered in the test report. Before the end of the test the fire should be burned low, just as before the start and then cleaned so that it will have as nearly as possible the same thickness and condition as at the start. Likewise, bring the water level to as nearly as possible the same height as at the start. One way to gage the thickness of the fire is to drop the rake into it so that the tines touch the grate bars and then note the distance they have been buried in the fuel bed. For convenience in keeping the water level uniform a string is tied around the gage-glass at the level of the water at the start. With an automatic feed-water regulator this is unnecessary but still it is a good thing to have the string there simply as a check on the regulator.

Test Report

Table 1 shows the standard form of reporting boiler tests. It has been slightly changed and abbreviated to suit practical cases and filled in with data from an imaginary test so that it may be taken as a model for regular use.

The number of men required to conduct a test depends upon the number of different observations to be made, the interval of time between them and the arrangement of the boiler accessories and testing apparatus; hence, no definite directions can be given on this matter. If all readings are taken every 15 min., which is the customary interval when complete data are desired, in addition to one man for measuring and recording the feed water and one man for the coal, at least one extra man will be required to analyze the flue gases and perhaps a fourth man will be needed to observe temperatures, pressures, etc. Each man should be provided with a suitable chart or paper which should, if necessary, be ruled off so that the time of each reading as well as the reading itself may be noted down without confusion and undue danger of error. At the end of the test each set of readings is added up and divided by the total number of times which that particular reading has been recorded so as to get the average, which is then entered in its proper place on the report form. The total coal and water quantities are also entered upon the report, as indicated in Table 1.

In order to present an actual practice problem with which those who wish may test their grasp of the subjects involved, only data and not results have been en-

tered in Table 1. The results and the calculations necessary to estimate them will be given in full in next week's lecture. The average temperature shown by the thermometer on the exhaust side of the calorimeter may be taken as 272 deg., for the imaginary test.

TABLE 1. BOILER-TEST REPORT FORM

Data and results of evaporative test

made by..... Arthur Jones and assistants
Of....A Heine type water-tube boiler
At....Plant of Smith Mfg. Co., New York City.
To determine....Efficiency under actual operating conditions.

Kind of fuel	No. 2 buckwheat
Kind of furnace	Hand fired with shaking grates
State of weather	Fair, with average temperature at 37 deg
Method of starting and stopping	Alternate
Date of test	Feb. 13, 1913
Duration of test	10 hr.

Dimensions and Proportions

Grate surface	Width, 8 ft. 10 in.; length, 7 ft.; area, 62 sq.ft
Height of furnace	34 in.
Water-heating surface	2150 sq.ft.
Superheating surface	None

Average Pressures

Steam pressure by gage	103 (abs.) lb. per sq.in.
Draft at damper	0.9 in. of water
Draft in furnace	0.6 in. in water
Difference in draft between furnace and damper	0.3 in. of water
Difference in draft between ashpit and furnace	0.6 in. of water

Average Temperature

Air in fire room	92 deg.F
Feed water entering boiler	199 deg.F
Gases escaping from boiler	540 deg.F

Fuel

Total weight of coal as fired	10,372 lb
Moisture in coal as fired	7 percent
Total weight of dry coal supplied to furnace	lb
Total weight of ash and refuse	1897 lb
Percentage of ash and refuse in dry coal	lb

Proximate Analysis of Coal

	Coal as fired per cent.	Dry coal per cent.	Combustible per cent.
Moisture	7.	.....	.....
Volatile matter	3.49	.....	.....
Fixed carbon	76.35	.....	.....
Ash	13.16	.....	.....
Total	100.	.....	.....

Analysis of Ash and Refuse

Combustible matter	per cent.
Incombustible matter	per cent.

Fuel per Hour

Dry coal consumed per hour	lb.
Dry coal per sq.ft. grate per hr.	lb.

Heat Value of Fuel, B.t.u. per Pound

	Coal as Fired	Dry coal	Combustible
By calorimeter	.....	12,600	.....
Estimated	.....	.....	.....

Quality of Steam

Moisture in steam	per cent.
Superheat	deg.
Total weight of water fed to boiler	83,125 lb.

Water per Hour

Water fed	lb. per hr
Water actually evaporated (corrected for moisture in steam	lb. per hr
Factor of evaporation	
Actual equivalent evaporation	lb. per hr

Horsepower

Horsepower developed	
Builders' rated horsepower	220
Percentage of builders rating, developed	

Economic Results

Water apparently evaporated, actual conditions per pound of coal as fired	lb
Actual equivalent evaporation per lb. coal as fired	lb
Actual equivalent evaporation per lb. dry coal fired	lb
Actual equivalent evaporation per lb. combustible burned	lb

Efficiency

Efficiency of boiler (heat absorbed per lb. comb. burned divided by heat value of 1 lb. comb.)	per cent.
Efficiency of boiler and grate (heat absorbed per pound of coal fired divided by heat value of 1 lb. coal)	per cent.

Cost of Evaporation

Cost of coal per ton of 2,000 lb. delivered in furnace	$2.90
Cost of coal used for evaporating 1,000 lb. water from and at 212 deg.	

Analysis of Flue Gases

Carbon dioxide (CO_2)	10.7 per cent.
Oxygen (O)	8.7 per cent.
Carbon monoxide (CO)	0.4 per cent.
Nitrogen	

Method of Firing.

Kind of firing (spreading, alternate or coking)	spreading
Average thickness of fuel bed	5 in.
Average time between firings for each furnace during time when fires are in normal condition	11 min.
Average time between leveling or breaking up	32 min.
Average time between cleanings	5 hr.

Industrial Power in the United States

Increased use of gas engines and of electric power, especially the latter, is the most striking and significant showing made in the abstract of figures from the thirteenth census, tabulating the figures as to engines and power used in the manufactures of the United States. It has taken the Census Office nearly three years to make this compilation, the figures given being for 1909.

The total horsepower of electric motors in use in 1909 was 4,817,140, as compared with 492,936 in 1899, or an increase of nearly a thousand per cent., while the number of electric motors increased from 16,891 in 1899 to 73,119 in 1904, and in 1909 was 388,854. The increase in the number of gas engines in use in the last five-year period was nearly twice as great as in the first half.

Total horsepower of manufacturing establishments was 18,680,776 in 1909, as compared with 13,487,707 in 1904 and 10,097,893 in 1899. Ninety per cent. of the horsepower in 1909 was that of motors owned by the manufacturing establishments, and 10 per cent. was rented power, most of the latter being electric.

The primary power used, with the kind of engines, is shown in the following table. These figures exclude duplications, and the secondary power is not represented in the total given.

Power	Number of Engines or Motors			Horsepower		
	1909	1904	1899	1909	1904	1899
Primary power total	408,472	231,363	168,143	18,680,776	13,487,707	10,097,893
Owned	209,163	169,774	168,143	16,808,106	12,854,805	9,778,418
Steam	153,482	127,267	130,710	14,202,137	10,825,348	8,139,579
Gas	34,352	21,515	14,334	754,083	289,423	134,742
Water wheels	20,126	19,595	23,099	1,807,144	1,641,949	1,454,112
Water motors	1,203	1,397	(*)	15,449	5,931	(*)
Other	.....	.....	.....	29,293	92,154	49,985
Rented	199,309	61,589	(*)	1,872,670	632,902	319,475
Electric	199,309	61,589	(*)	1,749,031	441,589	182,562
Other	.....	.....	.....	123,639	191,313	136,913
Total Electric motors	388,854	73,119	16,891	4,817,140	1,592,475	492,936
Current generated by establishment	189,545	73,119	16,891	3,068,109	1,150,886	310,374
Rented power	199,309	(*)	(*)	1,749,031	441,589	182,562

(*) Not reported.

Wide differences among the industries with respect to the kind of power and engines used are shown by the figures reported for the 43 leading industries of the country. While some of these differences are ascribed to geographical location of establishments, no attempt is made to explain which are due to this, and which are due to the character of machinery used and the adaptability of different kinds of power to the industries. The figures show a very large percentage of power generated by gas engines to be used in the manufacture of carriages and wagons, flour mills and grist mills, foundries and machine shops, blast furnaces, steel works and rolling mills, lumber mills and printing establishments.

Waterwheels are used mainly in four industries—cotton mills, flour and grist mills, lumber mills and paper and wood-pulp manufactures. In the last-named industry, 60 per cent. of all the power used in the industry, or 783,311 hp., is developed by waterwheels.

Despite the increasing hydroelectric development in the Rocky Mountain and Pacific states, at Niagara and in New England, steam continues to be the most important source of power in every state of the union except Maine and Vermont. The census figures do not attempt to show the use of various kinds of fuel in steam development, nor the amount of hydroelectric power developed, this latter important item being added in a total with all other secondary power developed.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

With intelligent development of the electrical industry, says a prominent financier, the next five years should absorb $400,000,000 a year. The size of this wad makes us believe that the p. f. must have included the operating engineers' salaries, too.

❖

For a year and a half, Mrs. Lena Williams has taken complete charge of the day shift of the Westbury Electric Light & Power Co. plant, at Cookshire, Quebec, "with perfect satisfaction to the owners as well as to the customers." She is the daughter of the manager and the wife of the electrician. Now, now! Any lady who can get away with such a job is to be admired.

❖

Massachusetts man declares that the public no longer believes electricity to be a luxury; that the rich and poor alike need and demand it. And yet in some homes you never hear the old man say: "Hey, Timmy, on your way out for the pint, slip down into the cellar and jab this quarter in the meter; the tungsten in the butler's pantry is getting dim!"

❖

A central-station enthusiast would have us believe that coöperation, and not competition, is the life of trade. Many an isolated plant would gladly do a little coöperation if its competition, the central station, would loosen up.

❖

The Federation of Trade Press Associations is convened in New York City at this writing. This organization is a publishers' "N. A. S. E.," and, similarly, in convention, we jaw each other for our mutual good. This federation represents 5900 folks drawing annually $12,272,000 in salaries on publications having an added expense annually of $15,000,000. Perhaps, in one of your few sour moments, you thought we overjawed you on the efficiency of your vocation. Well, as a good physician we took a dose of our own medicine, and now that we are purged of more or less bile, we feel better. You know that old feeling of "It hurts me more than it does you, my son"—well that's it exactly.

❖

Roy Wright, over to Lyndon, Kan., opines that "where ignorance is bliss, 'tis folly to be a blister." Here's his reason:

"Engine Blows Up—The gasoline engine owned by Will Duncan, being used to furnish power for the rock crusher on the Warren farm just east of Lyndon, was rendered useless Friday, by an explosive induced by a lack of water. No one was hurt. The fire box and crown sheet were crumpled up like paper and the boiler iron was crystallized making those parts of poor junk."

Thanks, Roy. Our condolence to Will Duncan.

❖

Our British cousin has been called undemonstrative, cold, reserved, but gracious Scott! the London "Electrical Review's" report of a railway disaster should completely telescope this opinion. After you read this introduction you will tell Hall Caine and Marie Corelli to precipitately retreat rearwardly:

"Lest we forget! Oh! that we could forget Aisgill! Oh! that we might for once shirk our duty and refrain from again perusing the ghastly details of one of the most heart-rending and pitiful of the avoidable catastrophes which have blackened the pages of British railway history. That we might wake up to find it to have been a distressing nightmare! That we might close the book and say: What a very sensational piece of holiday fiction! But it cannot be."

And there's two pages of this! Our sympathy always goes out to any stricken community, but this isn't sympathy, it's piddling drool!

❖

It's a cold weather this winter, Mawruss! A high forehead with the sweetly sounding name of Kamerlingh Onnes has already produced a temperature of 426 deg. Fahr. below zero. Liquefied gas did it, but we don't want to prove it.

❖

It would take over a thousand years to count the molecules in a cubic millimeter of hydrogen gas, says a French mathematician. All right, old man, we agree with you; we take the count.

Under-Water Coal-Storage Plant

A unique coal-storage plant has recently been erected by the Indianapolis Light & Heat Co., Indianapolis, Ind., where provision has been made for submerging 13,000 tons of coal under water to prevent spontaneous combustion. The plant has a total storage capacity of 30,000 tons and provides against coal shortage due to strikes at the mines or on the railroads and to car shortage on the railroads.

The plant consists of a large concrete pit, as shown in the illustration, 300 ft. long by 100 ft. wide and 28 ft. deep. It is 18 ft. below the ground level, having a 10-ft. wall rising above the ground. Below the ground the wall slopes at an angle of 45 deg. to reduce the cost of construction. This makes the pit 72 ft. wide by 272 ft. long on the bottom. The concrete is from 12 to 18 in. thick and is reinforced throughout with twisted ½-in. square rods to withstand any pressure from water that may occur in the gravel around the pit.

LOCOMOTIVE CRANE AND GRAB BUCKET

Through the middle of the pit, lengthways, there is a row of concrete piers placed 15 ft. apart which support a trestle on which there runs a standard-gage track. A standard 15-ton Brownhoist locomotive crane and 2-yd. grab bucket travels back and forth on this trestle, handling the coal on both sides. The bucket is suspended on a 40-ft. boom. The crane and bucket are operated by one man from his stand in the cab. Being self-propelled and equipped with M. C. B. trucks, couplers and steam brake, the crane does the switching of the cars off and on the trestle. The coal cars are run out on the trestle with the crane and dumped. When the coal is required in the power house it is loaded into cars by the crane and carried to the boilers.

Forty-pound rails are imbedded in the bottom of the pit, on 18-in. centers, with ½ in. of the head standing above the surface of the concrete. When the grab bucket is working on the bottom of the pit, the rails prevent the bucket from striking the concrete.

The pit is filled with water up to the ground level, and

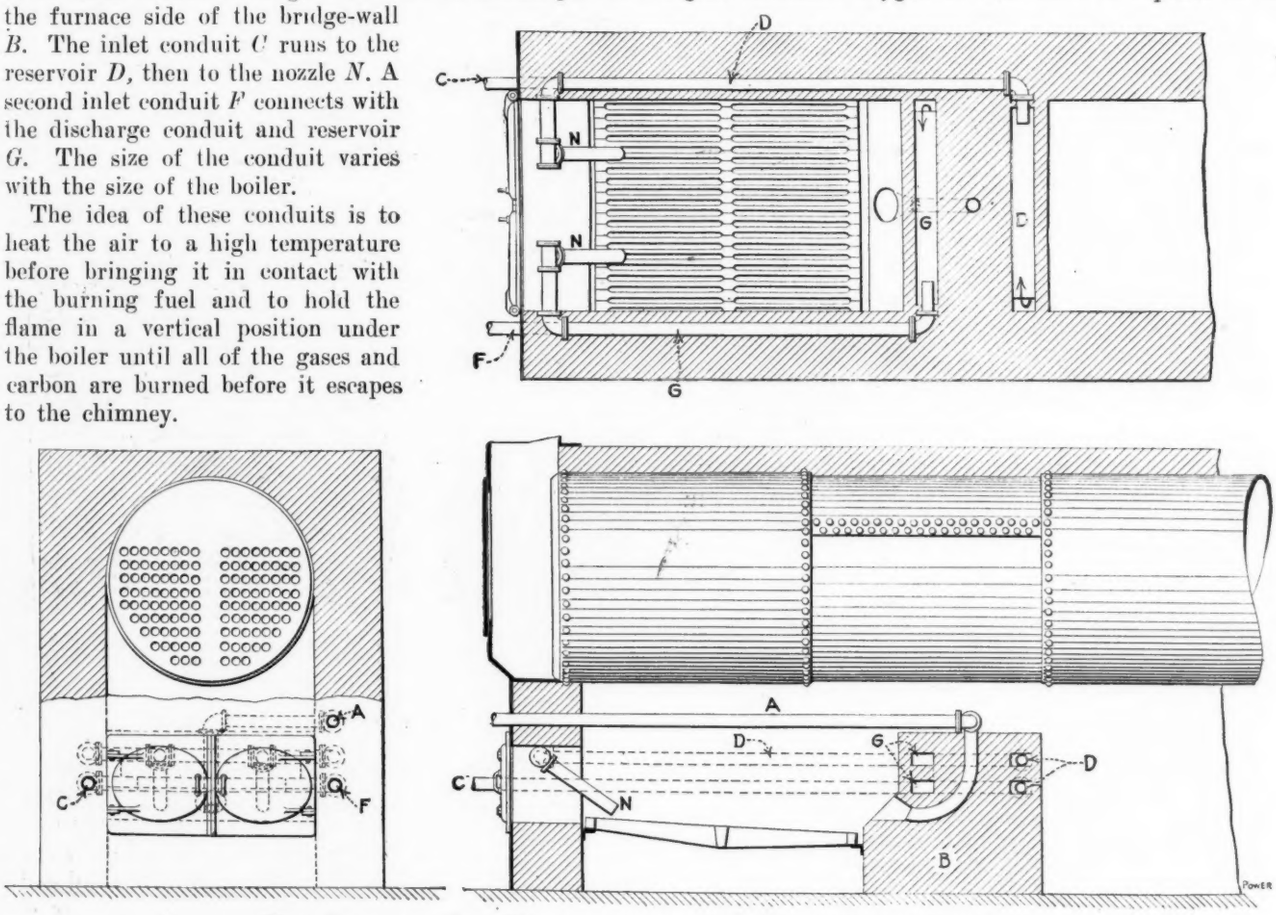
covers 13,000 tons of coal. Water is pumped into the pit by a 4-in. centrifugal pump, taking the water from the power-house supply well, the water entering the pit at the ground level. Through the center of the pit and beneath the trestle there is a trough 12 ft. wide and 1 ft. deep which serves as a drainage. It is fitted with a drain pipe which carries the water to either of two manholes, one at each end of the pit. The outlet openings are protected by gratings to prevent any coal from entering the drain pipe.

The pit was designed by Thomas A. Wynne, vice-president of the company, and was built under his supervision.

McKee Boiler Furnace

This furnace is designed to burn fuel efficiently with a minimum of smoke and to operate economically with a short chimney. In the accompanying illustration is shown an end, side and top view of the furnace applied to a return-tubular boiler. Referring to the side elevation, *A* is an inlet conduit through which air is discharged on the furnace side of the bridge-wall *B*. The inlet conduit *C* runs to the reservoir *D*, then to the nozzle *N*. A second inlet conduit *F* connects with the discharge conduit and reservoir *G*. The size of the conduit varies with the size of the boiler.

The idea of these conduits is to heat the air to a high temperature before bringing it in contact with the burning fuel and to hold the flame in a vertical position under the boiler until all of the gases and carbon are burned before it escapes to the chimney.



END, PLAN AND SIDE ELEVATION OF THE MCKEE BOILER FURNACE

The air passes through the arrangement of conduits which run parallel with the line of fire from the front or the back of the boiler to the bridge-wall through a reservoir in the same and back to the ashpit of the boiler furnace and then comes in contact with the burning fuel. A counter-current of air is heated in a like manner and discharged in a forward direction from the bridge-wall toward the front of the furnace.

The furnace is built by the McKee Furnace Co., 108 Prince William St., St. John, N. B., Canada.

Spontaneous Ignition of Coal

By T. A. Peebles

Manufacturing establishments, central stations, and other users of large quantities of coal find it necessary, to keep considerable quantities of fuel on hand to insure against labor troubles or delays in transportation. The coal thus kept in storage is in constant danger of spontaneous ignition, and in some cases expensive submerged storage bins have been installed or other elaborate precautions taken to prevent it. In cases where such construction is not practical, care should be taken to select for storage, coals which are least liable to spontaneous ignition, and a knowledge of the conditions affecting this ignition is, therefore, valuable.

The process of ignition may be divided into four separate stages:

1. Certain volatile constituents are present in coal which have an avidity for oxygen, and freshly mined coal begins to absorb oxygen as soon as it is exposed to the air. This primary stage of the oxidation process causes an increase in the temperature of the coal which may be considerable if the coal is finely divided and thus exposes a large amount of surface to the air.

2. If the coal contains an appreciable amount of iron pyrites, a reaction between the sulphur of the pyrites and oxygen will occur at ordinary temperatures. This reaction takes place rapidly, especially if the coal is wet, and heat is generated more rapidly than it is radiated from a large pile of coal, with the result that the interior

of the pile may reach a temperature at which oxidation of carbon and hydrogen begins.

3. The hydrocarbon compounds begin to break down at a temperature of about 250 deg., F., and if even a small amount of oxygen is present, this stage of combustion is extremely dangerous on account of the large amount of heat evolved.

4. After a temperature of 400 deg., F., is reached, the combustion of carbon and hydrogen goes on without the assistance of any outside source of heat, and heat is generated at such a rate that the cooling effect of radiation will not be sufficient to stop the process. Actual ignition of the carbons begins as soon as the temperature rises to 600 or 700 deg., F.

From the foregoing, it is evident that some coals are better suited for storage purposes than others. If the third stage of the ignition process be reached, actual combustion is almost sure to result eventually, and the first and second stages are, therefore, most important. The following points should be carefully considered as affecting the spontaneous ignition of coal in storage:

Avoid any external source of heat which may raise the initial temperature. For any given coal, a definite amount of heat is generated and if the initial temperature be high, due to the application of external heat, the danger of spontaneous ignition is increased. Coal stored in overhead bunkers in a boiler room where it is exposed to the heat of the boilers from below, and the heat of the sun radiated from the roof above, is almost sure to be ignited.

Dryness of the coal and provision for keeping it dry will greatly reduce the oxidation of iron pyrites.

Fine particles present large surfaces to the air for the initial stages of oxidation and the elimination of such particles from coal intended for storage is desirable.

When shipments of coal are being received, part of which is to be used immediately and the balance stored, that which is wet or very fine should be burned, and the coarser grades and those free from moisture put into storage.

Compensating Device for Water Measurement

On page 389 of the Sept. 16 issue was described a compensating device used with the Lea type recorder as manufactured under English patents. The instrument is known as the Precision Water Meter in this country and is made by the Precision Instrument Co., 102 Randolph St., Detroit, Mich., with the new compensating notch incorporated in its design.

Bangs (Ohio) Steam-Engine Wreck

On Sept. 11, about 4:30 a.m., the engine used for lighting the Logan Natural Gas & Fuel Co. pumping station at Bangs, Ohio, was wrecked. A correspondent furnishes the following details:

The babbitt in the crank bearing melted out, and an engineer closed the throttle only a moment before the wreck occurred.

The connecting-rod was of the marine type, setscrews took the place of lock nuts, and apparently a nut had worked nearly off, as no threads were stripped and one end was torn off. The bolts were badly bent, both halves of the crank bearing, the crosshead, and both crosshead shoes were broken; one of the low-pressure cylinder heads had a part of the flange broken off, and the cast-iron top cover to the crank case was broken as was the connecting-rod. The greater part of the crosshead and parts of both shoes flew out over the counterweights onto the floor. It was a 144-hp. tandem-compound engine, running at 260 r.p.m., and was directly connected to a direct-current 75-kw. dynamo.

Smoke Convention at Pittsburgh

The eighth annual convention of the International Association for the Prevention of Smoke was held in Pittsburgh, Penn., Sept. 9 to 12.

Among the papers presented was one on stokers for locomotives, by Mr. Crawford, superintendent of motive power for the Western division of the Pennsylvania Railroad. Mr. Crawford described the stoker and told of its success in producing practically smokeless combustion in locomotive furnaces.

Mr. Smith, of Glasgow, spoke on the favorable progress made in smoke abatement in Scotland.

The Committee on Standardization intends to present a thorough report on its work of standardizing furnace, chimnies, draft systems, etc., at the next convention in Grand Rapids, Mich. We hope to soon publish brief abstracts of Mr. Crawford's paper and of the Standardization Committee's report.

The new officers are: President, J. M. Searle, chief smoke inspector for Pittsburgh, Penn.; vice-president, Louis E. Towner, Grand Rapids, Mich.; secretary, John Krause, Cleveland, Ohio.

SOCIETY NOTES

The Smoke and Dust Abatement League of Pittsburgh is to be congratulated on the good results thus far attained in its work. Its exhibit at the Western Pennsylvania Exposition has drawn wide attention—by showing by charts, maps and drawings the serious loss yearly suffered by the city of Pittsburgh through smoke and dust. The exhibition will be open to the public until Oct. 18.

The Pennsylvania Industrial and Efficiency Convention, under the auspices of the Engineers Society of Pennsylvania, will be held in the Capitol Building, Harrisburg, Penn., on Oct. 28, 29 and 30. George S. Comstock, president of the society, will preside. Among others, papers will be read at the state-service session on vocational education, water power and water conservation; at the labor and statistics session, heat, ventilation and light; at the accident-prevention session, coöperative boiler inspection; elevators, their construction, inspection and maintenance.

Persons attending the conference are asked to notify the Department of Labor and Industry, Harrisburg, Penn., to that effect, and those who wish to make exhibits to write the Director of Exhibits, Harrisburg, Penn., in regard to space, etc.

PERSONALS

Herbert E. Stone, past president of the National Association of Stationary Engineers, has accepted a position with the Buckeye Engine Co., of Salem, Ohio, and will have charge of the New England district.

Albert E. Guy has just terminated a two-years' engagement with the Wilson-Snyder Centrifugal Pump Co., of Pittsburgh, Penn. In his capacity as chief engineer for that company, he designed and established their complete lines of single and multi-stage centrifugal pumps for steam turbine and motor drive. While still retained as consulting engineer, by that company, he will become, Sept. 15, mechanical engineer of the Providence Engineering Works, Providence, R. I.

An "Acre-Foot" of Water is equivalent to 43,560 cu.ft. and is the quantity required to cover an acre to the depth of 1 ft. The term is commonly used in connection with storage for irrigation.

What Has The Ameri
Got To Do Wi

Ever hear the story of the rube who went to the circus?

Wandering into the menagerie he presently found himself in front of a cage containing a giraffe.

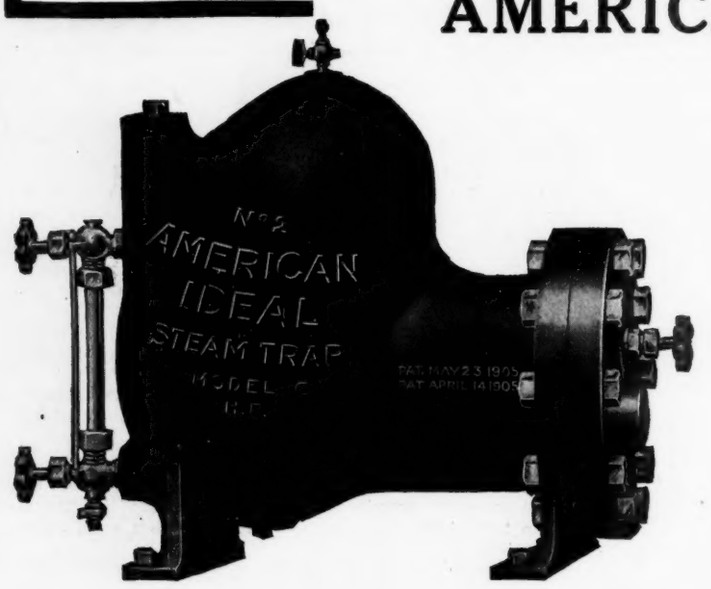
For a long time he stood looking at it, open-mouthed, then finally turned away with the remark, "Shucks; there aint no such animal."

Maybe that's much the same attitude you'll assume toward the American Ideal Steam Trap.

The things which this trap accomplish seem almost too good to be true. When you stop and think of what it does and how it promises to solve the big problem of meeting the very highest pressure you're likely inclined to say, "There isn't such a trap."

But just the same there IS—and it's the American Ideal.

The trouble you engineers have had in the past with traps which have failed to stand up to the severe requirements of very high pressures has made you skeptical.



AMERICAN STEAM GAUGE
CAMDEN STREET,